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ACCOMMODATING INDIVIDUAL DIFFERENCES DURING EXTERNALLY PACED PROGRAMED INSTRUCTION, REPORT 3--STUDIES IN TELEVISED INSTRUCTION, INDIVIDUALIZING GROUP INSTRUCTION.

BY- GROPPER, GEORGE L. KRESS, GERALD C., JR.
METROPOLITAN PITTSBURGH EDUC. TV STATION, PA.

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THE RELATIVE EFFECTIVENESS OF ALTERNATE APPROACHES TOWARD INDIVIDUALIZATION OF FIXED-PACED PROGRAMED INSTRUCTION WAS ASSESSED. THIS REPRESENTED THE THIRD IN A SERIES OF THREE STUDIES CONCERNING THE RELATIONSHIP BETWEEN PACING MODE AND BEHAVIOR. (REFER TO ACCESSION NUMBERS ED 003 199, ED 003 200, AND ED 003 202 FOR ADDITIONAL INFORMATION ON THIS PROJECT.) PROGRAMED LESSONS IN SCIENCE WERE PRESENTED OVER TELEVISION TO EIGHTH-GRADE STUDENTS. A TOTAL OF 12 SEPARATE VERSIONS WERE COMPARED, INCLUDING 3 VERSIONS DIFFERING IN PROMPTING STRENGTH AND PRESENTED AT 4 DIFFERENT TEMPOS. COMPARISONS WERE MADE AMONG TREATMENTS FOR ERRORS, POST-TEST SCORES, AND RETENTION SCORES. WHILE ADDED PROMPTING DID REDUCE ERROR RATES, IT ALSO LED TO LOWER ACHIEVEMENT. ITS POTENTIAL VALUE IN OVERCOMING THE DETRIMENTAL EFFECTS OF FIXED PACING WAS DISCOUNTED. INTERACTIVE TRENDS WERE OBSERVED BETWEEN CHARACTERISTIC WORK RATES AND TEMPO VARIATIONS. MULTIPLE PROGRAM SOURCES WERE DISCUSSED AS MEANS FOR PROVIDING EFFECTIVE AND EFFICIENT GROUP INSTRUCTION. (JC)

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STUDIES IN TELEVISED INSTRUCTION

INDIVIDUALIZING GROUP INSTRUCTION

3. ACCOMMODATING INDIVIDUAL DIFFERENCES DURING EXTERNALLY-PACED PROGRAMMED INSTRUCTION

Gerard C. Kress Jr.
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METROPOLITAN PITTSBURGH EDUCATIONAL TELEVISION STATION
and the AMERICAN INSTITUTES FOR RESEARCH

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STUDIES IN TELEVISED INSTRUCTION

3. ACCOMMODATING INDIVIDUAL DIFFERENCES DURING EXTERNALLY-PACED PROGRAMMED INSTRUCTION

Gerard C. Kress, Jr., Project Director
and
George L. Gropper, Principal Investigator

NOVEMBER 1964

METROPOLITAN PITTSBURGH EDUCATIONAL TELEVISION STATION
and the AMERICAN INSTITUTES FOR RESEARCH

FOREWORD

The research reported in this volume was conducted under a grant from the U. S. Department of Health, Education, and Welfare, Office of Education, under title VII, the National Defense Education Act of 1958, Project No. 872, Grant No. 7-48-0000-159. Data analyses were partially supported by a National Science Foundation grant (No. G-11309) to the University of Pittsburgh Computing Center.

The proposal for this project was based on an award-winning research plan submitted by the Principal Investigator to the Television Research Plans Competition sponsored by the Television Bureau of Advertising (Gropper, 1963)*.

The authors are grateful to numerous people for their participation and cooperation in this project including: Dr. Evan Ingram of the Pittsburgh City Schools and Sister Rosalie of the Diocesan Schools in Pittsburgh for their help in enlisting the participation of pupils and teachers in this project; to the staff of WQED for their work in the production of televised lessons used in the project; to Charlotte Conley and Martha Scott for their aid in reproducing this report; and to Margaret Samways and Zita Glasgow for their preparation of programmed materials used in the study.

George L. Gropper
and
Gerard C. Kress, Jr.

December 1964

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*Gropper, G. L. An experimental evaluation of procedures for "individualizing televised instruction. In L. Arons & M. A. May (Eds.) Television and Human Behavior - Tomorrow's research in mass communication. New York: Appleton-Century-Crofts, 1963.

ABSTRACT

Students can learn effectively from programmed materials even when they are presented at an externally selected, fixed pace rather than at a self-adopted pace. The fixed pace or tempo selected, in order to accommodate a group heterogeneous in ability or in pacing requirements, generally, is too slow to be compatible with efficient learning. The purpose of the present experiment is to assess two strategies whereby greater efficiency might be attained. One strategy involves added response prompting to enable the use of a single program source presenting material at a faster, fixed tempo. The second strategy involves an assessment of the value of separate program sources for separate groups homogeneous with respect to their characteristic work rates.

Programmed lessons in science were presented over television to eighth grade students. Twelve separate versions were compared, including three versions differing in prompting strength and with each of these versions presented at four different tempos. Comparisons were made among treatments for errors, posttest scores, and retention scores.

The results provided tentative support for the approach involving multiple program sources to accommodate individual differences during fixed-paced instruction. While added prompting did reduce error rates, it also led to lower achievement. Its potential value in overcoming the detrimental effects due to fixed pacing was therefore discounted. On the other hand, interactive trends were observed between characteristic work rate and tempo variations. While these observations were not all statistically significant, the general trend observed was uniform.

In order to learn effectively, characteristically slow workers do indeed appear to require a slow fixed-tempo. The imposition of the same tempo upon characteristically fast workers results in a drop in the effectiveness as well as the efficiency of their learning. These findings suggest the need for at least two program sources, each delivered at a tempo appropriate to the pacing requirements of its viewers.

Multiple program sources seem indicated in the interest of both effective and efficient group instruction. If this dual goal is reached, individualization of group instruction may be thought to have been accomplished despite the fact that the pace used to bring it about is externally controlled and constant for all individuals in a group.

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INTRODUCTION

An instructional strategy for teaching a particular skill or a particular subject matter may often call for the use of film or television. For example, either learning how to perform experiments in science or learning the concepts and principles illustrated by visually presented demonstrations may be facilitated by the use of film or television. For either purpose, the presentation used is necessarily fixed-paced, not because the instructional strategy calls for fixed pacing, but because it calls for the use of a medium which happens to be fixed-paced. There are other instructional situations where it is fixed pacing per se that may be called for.

The suggestion was made in Report #2 in this series (Kress & Gropper, 1964b) that individualization of instruction might, under appropriate circumstances, best be accomplished by assigning students to instructional settings which are fixed-paced rather than self-paced. Students who, when allowed to pace themselves, work at a non-adaptive pace, either too fast or too slow, might require such treatment (Kress & Gropper, 1964a). Learning effectiveness or learning efficiency might thereby be improved. The problem arises, of course, of determining an appropriate fixed pace so that it, too, does not become non-adaptive.

Whereas the teaching machine or programmed book allows each student to work singly, at whatever pace he adopts, when group media are used, more than one person must work together at a pre-selected pace. Since the range of paces adopted by individual students, when allowed to do so, is quite wide, it seems reasonable to expect that applying techniques of programmed instruction to such group media as film or television will necessarily require the selection of a pace which can accommodate a variety of pacing needs.

One possibility is to attempt to "individualize" instruction. More than one lesson can be developed with each lesson differing in pace to make it appropriate for students differing in pacing requirements. In addition, homogeneous groups can be formed with each group receiving instruction specifically tailored to its needs. The purpose of the present experiment

is to explore the potential advantages of these strategies by analyzing the interactive effects between several externally selected tempos and individual differences among students in ability and work habits.

The earlier experiment in this series involved three externally fixed tempo levels and produced results showing that such individual difference variables as IQ and average work rate (self-adopted pace during self-paced instruction) were determiners of performance under fixed-paced conditions (Kress & Gropper, 1964b). The effect of externally controlled tempos on performance was clearly not uniform for all types of students. Students of above-average ability performed better than below average students. Students characterized by faster than average work rates performed better than students of slower than average work rates. There was also a tendency for interactions to occur between these variables and tempo variations. The replicability of such findings could provide guidelines for assigning students to subgroups. Each subgroup would be assigned to one of several versions of a lesson, each presented at a different pace or tempo. The present experiment represents an attempt at such a replication, but with a broader and hence more representative range of tempos than was employed in the initial experiment.

The tempo ranges of the initial experiment were not sufficiently wide to produce significant reductions in achievement. However, as the externally selected tempos were increased, error rates did increase significantly. While error rates were apparently not critically high, it is likely that reduction in achievement levels, mediated by still higher and critical error rates, would occur if the pace were made fast enough. Given this possibility, the present experiment is therefore also concerned with problems of finding ways to modify the learner's task so that, even if increases in tempo occur, errors can be kept low and achievement high. With the availability of such adaptive techniques, it might be feasible to create substantial savings in time by requiring <u>all</u> students to work at a more rapid pace without serious decrement in performance.

Results of research on response modes suggest one possiblity for offsetting the detrimental effects of increased tempos. It would consist of added prompting for each response as a means of facilitating its rapid, correct performance. If this could be accomplished without impairing the

achievement levels produced by such response practice, trade-offs between satisfactory achievement levels and efficient utilization of time might not be necessary.

A study reported by Della-Piana (1961) provides some support for the expectation that added prompting might be capable of reducing errors and time requirements without also reducing achievement. Three levels of physical prompting were compared ranging from complete sentences which were to be read and copied to partially-completed sentences with blanks to be filled in. No differences in immediate or delayed achievement were found among the three levels of prompting employed. The results did, however, show that the more heavily prompted versions of the lesson required less time for completion and were shown to be more efficient as measured by achievement per unit of time. Studies on response mode by Alter and Silverman (1963), Cook and Spitzer (1960), and Goldbeck and Campbell (1962), provide additional evidence that added prompting reduces learning time requirements. A finding common to all studies was that simply reading (maximal prompting) programmed materials leads to greater efficiency. Students learned as much in less time by reading or copying as did students who filled in blanks. Still to be determined, however, is whether, when allotted less time under externally controlled tempo conditions, student performance is less impaired under more heavily prompted conditions.

The present experiment has been designed to investigate: (a) the effects on errors and achievement of speeding up presentation tempos; (b) the interactive effects of increased tempos and such individual difference variables as IQ and work rate; and (c) the interactive effects between increased tempos and increased prompting levels. If errors can be kept minimal by added prompting strength and at the same time achievement scores kept high, then it might be concluded that one program source, delivered at a relatively fast tempo and provided with the appropriate amount of prompting, might be adequate to accommodate the entire range of students in a given class efficiently. If, on the other hand, interactions occur between ability measures and tempo, then separate program sources, presented to appropriately constituted subgroups, would appear to be indicated. If, as a final possibility, the relationship between achievement and tempo is a uniform function for all types of individuals and irrespective of prompting

strength, then it would appear that neither separate program sources nor modified prompting effectively improves learning under externally-paced conditions. The purpose of the present experiment is to determine which of these strategies for accommodating individual differences is optimal for learning via fixed-paced, group media.

METHOD

Subjects

The sample of Ss who participated in this experiment consisted of 353 eighth-graders from eight separate classes drawn from four different schools in the Pittsburgh area.

Materials

Materials developed for this experiment included a set of preliminary, self-paced programs which were administered in the schools prior to the main experimental comparisons. The experiment proper was conducted at the studios of WQED and involved the use of a series of fixed-paced televised lessons which were recorded on tape.

(a) preliminary programs. - The preliminary materials administered in the schools included a short program designed to familiarize students with how to go through a program and two content programs, one on "atomic structure" and the other on the concept of "force." These programs were also employed in the initial study in this series and are described in detail elsewhere (Kress & Gropper, 1964a). Subjects were given these programs in order to provide them with experience in learning from programmed materials and to provide estimates of their characteristic, self-adopted work rates. The administration of the Atomics and Force programs was preceded and followed by the administration of identical forms of an achievement test. The tests used are also described in the earlier study (Kress & Gropper, 1964a).

(b) experimental programs. - The content prepared for use in the main experiment consisted of two separate lessons in the natural sciences. One was a 43-frame unit on the physical concept of "elasticity," the other a 44-frame unit on "direct and inverse relationships." Two separate units, in preference to a single unit, were used so as to allow Ss to begin afresh, on a new topic, in the middle of the experimental session. In this way cumulative effects of a poor start could be minimized. More important, consistent results for two independent lessons could lead to more generalizable conclusions.

Each lesson was programmed in the typical linear style, requiring constructed, verbal responses in each frame. The programs were prepared for frame-by-frame presentation over television. In addition, a series of short demonstrations was designed to accompany them. Each demonstration had as its purpose, the visual display of concrete examples relevant to each of the major concepts of the lessons. The demonstrations, unlike the verbal portion of the lesson, were presented in conventional, rather than programmed form. The lessons began with a demonstration, followed by a section of programmed, verbal material. The verbal presentation for every major concept in each lesson was preceded by a short demonstration segment. A total of nine segments were built into the lessons, four in the lesson on "relationships" and five in the lesson on "elasticity."

The achievement tests developed for each program appear in Appendix A. Each consists of fill-in and short-answer questions which are designed to sample the entire range of lesson objectives. Identical forms were employed as pretests, immediate posttests, and retention tests.

Preparation and tryouts of the experimental lessons and achievement tests were conducted with paid eighth-grade Ss until the average error rates were below the 10 percent level and average achievement was above 80 percent. The demonstrational segments of the lessons during these tryouts were simulated by sketches and a verbal explanation from E. Additionally, two tryouts of the demonstrations were conducted at the television studio with Ss working in booklets containing verbal programs related to the demonstrations. They viewed the demonstrations (done "live" in a separate studio) on a monitor and then worked on the verbal programs. After the basic textual and demonstration formats had been revised to a satisfactory point, the entire experimental segments were recorded on video tape. Twelve experimental versions of both the lesson on "elasticity" and the lesson on "relationships" were produced. Twelve versions were required to represent all combinations of levels of the independent variables, i.e., four levels of tempo and three levels of prompting.

(c) variations in levels of prompting. - Figure 1 shows a typical frame in each of its three forms of prompting. The base or Non-Prompted version is a typical linear frame with a blank provided for the response

word. The second or Partly-Prompted version contains the first letter of each response word, capitalized. The third or Fully-Prompted version includes the entire response in capital letters and underlined.

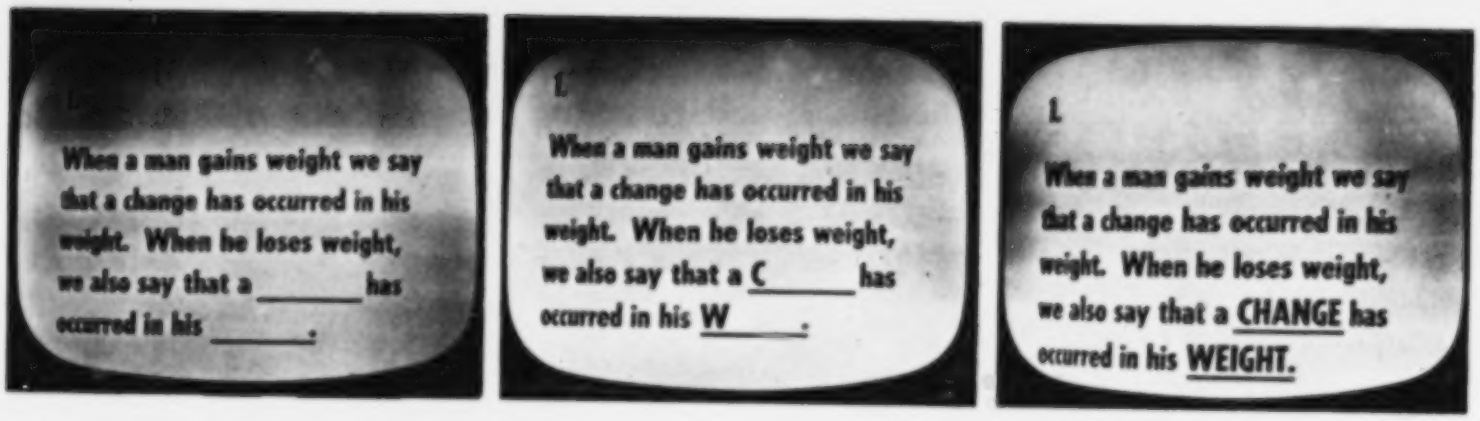
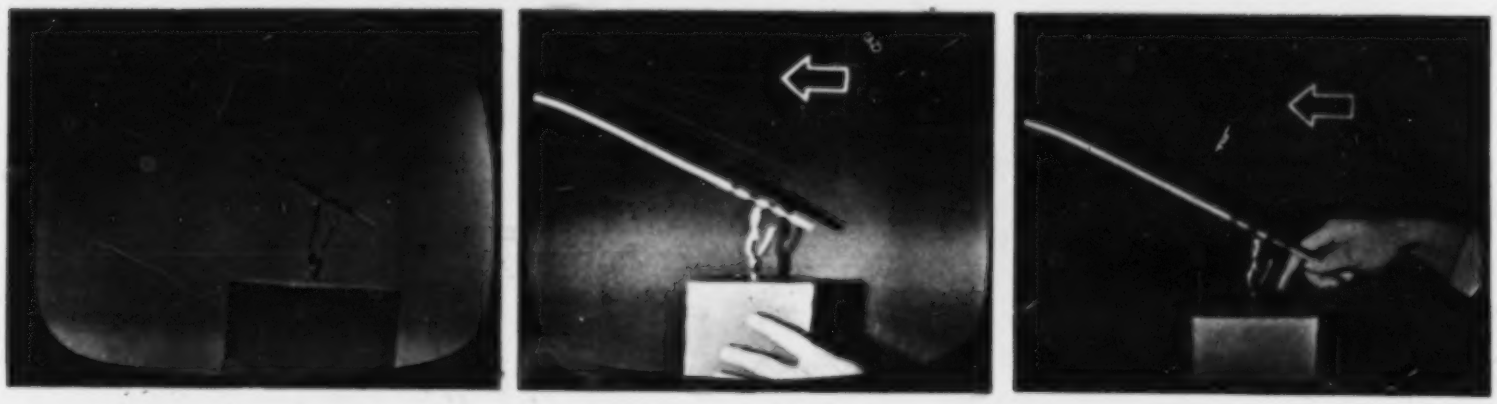

1.
When a man gains weight we say that a change has occurred in his weight. When he loses weight, we also say that a _____ has occurred in his _____.
1.
When a man gains weight we say that a change has occurred in his weight. When he loses weight, we also say that a C_____ has occurred in his W_____.
1.
When a man gains weight we say that a change has occurred in his weight. When he loses weight, we also say that a CHANGE has occurred in his WEIGHT.

Fig. 1. A sample frame in each of the three styles of prompting.

Prompting levels in the demonstration segments which accompanied each lesson were varied in a manner analogous to that used for the textual frames in the lesson. Starting from the basic demonstration, two additional versions were created, each with additional visual prompts to direct attention to key portions or events in the demonstration. Arrows, reference points, extra pointing by the instructor, or similar physical devices were added to indicate direction or the extent of movement, etc. The process is illustrated in Fig. 2 appearing on page 8 which shows the same portion of one demonstration at each of the three prompting levels.

Four versions of each of these prompting formats were produced, one at each of the four predetermined tempos.



Level 1 Level 2 Level 3

Fig. 2. A sample demonstration segment which illustrates the three levels of prompting.

(d) variations in levels of tempo. - The procedure for determining tempo levels was similar to that employed in the initial experiment in this series. A number of pilot Ss (n = 30) were given the preliminary Atomics and Force programs so as to provide a background similar to that which was to be provided for experimental Ss. They were then given the verbal portions of the programs on "elasticity" and "relationships" under self-paced conditions, and a record was kept of their times on each frame. All Ss were run individually and their times determined by E using a stopwatch. A distribution of working times was thus obtained for each frame of each program.

The initial experiment in this series (Kress & Gropper, 1964b) was judged not to have sampled a sufficiently wide range of tempos to have produced a sensitive measure of the detrimental effects that might be imposed by external pacing. The "fast" tempo level, in particular, was

judged not to have been fast enough. The method of determining tempo levels was accordingly modified somewhat for the present experiment. A base or slowest tempo was selected on the basis of the score of the third-from-slowest individual (rank 28 out of 30). The tempo level thus determined for this version of the lesson will be referred to as tempo level B. The successively faster levels will be called: B-1, B-2, and B-3. The time for each frame of the fastest of the four levels, B-3, was determined by the time required by the second-from-fastest pilot S who responded correctly to the frame. Levels B-1 and B-2 were based upon the times representing the 33rd percentile ($P_{33\text{-}1/3}$) and 66th percentile ($P_{66\text{-}2/3}$) of the overall distribution. This procedure resulted in a wide range of tempos, including a fast tempo which was judged to approach the limits of exposure durations still compatible with reasonable success on the programs.

Varying tempos were built into the demonstration segments in a manner consistent with the tempo variations for frames containing printed verbal materials. To begin with, each demonstration was performed in a manner which seemed clear and deliberate without effort to be slow in an exaggerated way. It was then performed, more rapidly, at a pace which was considerably faster, but not so much faster, in the judgment of Es, as to destroy its instructional value. The B-1 and B-2 versions of each demonstration were timed so as to fall at roughly equivalent intervals between the two extreme versions. Judgments about each of the several demonstrations were made arbitrarily, but with an effort to be consistent from demonstration to demonstration. That is to say, an effort was made to make the degree of separation between the slowest and fastest version of each demonstration approximately equivalent for all demonstrations. The range of times from slowest to fastest which resulted for the demonstrations was much smaller than that which characterized the presentation of the textual portions of the lessons.

The final stage of lesson preparation involved putting printed frames and demonstrations together to produce each of the twelve experimental versions. All demonstrations had been recorded on one tape and then each demonstration was dubbed electronically onto a tape containing the appropriate printed frames. The printed frames had been earlier

recorded from cards onto tape. Final tapes for all 12 experimental versions thus consisted of alternate sequences of demonstrations and printed frames, including audio directions regarding page turning, attending to demonstrations, writing answers, etc. These latter features were narrated as each tape was put together in final form. Fig. 3 and 4 illustrate the procedures used in recording the printed verbal frames.

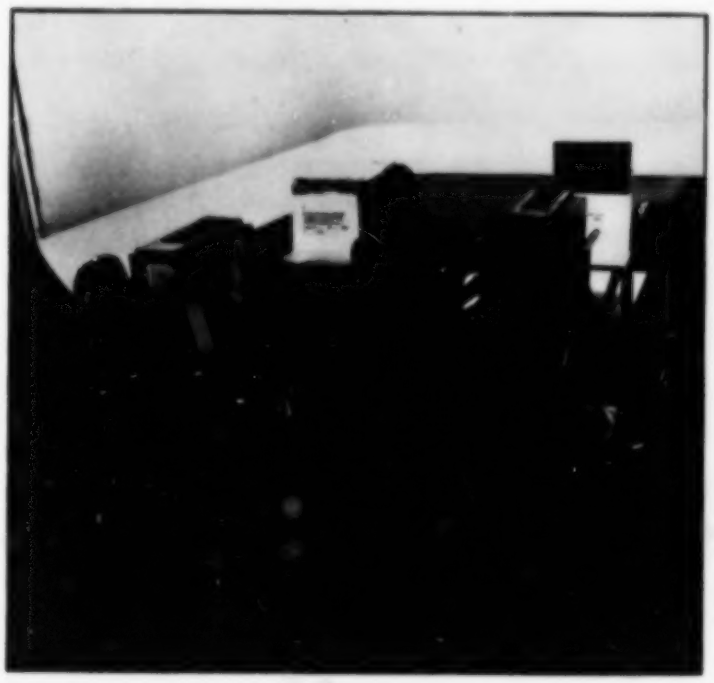


Fig. 3 and 4. Recording of printed verbal frames.

Twelve separate tapes were prepared in this manner, with each tape containing one complete lesson. For each of the three levels of prompting, four differently paced tapes were prepared with total running times of 34, 46, 58, and 87 minutes. The fastest versions therefore required approximately 39 percent of the running time of the slowest.

Experimental Design

As illustrated in Fig. 5, the experiment employed a 4x3 factorial design, with four levels of tempo and three levels of prompting. Subjects were assigned to the resulting twelve cells in such a way that each cell was equated with every other cell for average IQ and work rate.

Of the 300 Ss who participated in all preliminary sessions, 216 were labelled qualifiers, 84 as non-qualifers. The "qualifier" group had achieved posttest scores on the preliminary self-paced programs which averaged 70 percent or higher. Their time scores were thus considered to be reasonably valid estimates of their characteristic, self-adopted work rate. From the distribution of IQ's and work rates of qualifiers, groups of 12 Ss were selected so as to include the most similar Ss on both measures within a group. Assignment to cells or conditions was then accomplished randomly, i.e. with members of each group of 12 assigned at random to one of the 12 conditions. The purpose of this procedure, in addition to equating the groups of 12, was to enable levels analyses to be performed on the basis of both IQ and work rate. Thus, it would be possible to assess the interaction of the variables, IQ and work rate, with the experimentally manipulated variables, Prompting and Tempo.

The 84 Ss called "non-qualifiers" were assigned to the 12 cells in a similar fashion. However, the results for this latter group were intended to be used only in an analysis of the effects of two independent variables, tempo and level of prompting. They were not intended to be used in the levels analyses.

TEMPO

PROMPTING	B	B-1	B-2	B-3
Non-Prompted				
Partly-Prompted				
Fully-Prompted				

Fig. 5. The 4x3 factorial design employed in the fixed-paced experiment.

Procedure

(a) administration of preliminary materials in the schools. - The administration of all preliminary materials took place in Ss' regular classrooms. The general order and scheduling of these sessions is indicated in Table 1.

Table 1

Schedule of Administration of Preliminary Materials

DAY	TASKS	APPROXIMATE LENGTH OF SESSION
1	(a) Pretests: Atomics, Force, Elasticity, Relationships (b) Preliminary program	2 hours
	4-7 day delay	
2	Atomics Program and Posttest	2 hours
	7 day delay	
3	Force Program and Posttest	2 hours

The entire set of preliminary programs and their corresponding tests were administered in three sessions. The order of administration was identical for all classes, but the schedules of ongoing programs in the school dictated that some inter-task intervals vary slightly among classes. An interval of 16 to 19 days elapsed between the final session in the classrooms and the experiment at the television studios. All of the experimental sessions were conducted during February of 1964.

(b) conduct of fixed-paced experimental comparisons. - The 12 fixed-paced experimental conditions were carried out in one day, a Saturday. Three separate studios, each equipped with four television monitors, were used, making it possible for three conditions to be run simultaneously.

Subjects were scheduled so that four separate shifts in each of the studios were sufficient to complete all 12 conditions.

Monitors in each studio were arranged so that no more than eight Ss were required to view a lesson at each monitor. The desk-chairs were staggered in two or three rows so that every S had an unrestricted view of the screen. (See Fig. 6 and 7.)

Fig. 6 and 7. Typical seating arrangements during televised lessons.

Printed instructions were read to the Ss by E. Each S was given a copy of the answer booklet with numbered pages and appropriate blanks to record responses. An audio tone was employed in all versions to signal when the exposure time for each frame was half elapsed. Since the exposure intervals varied from frame to frame, this signal helped S to adjust to the particular tempo involved and to budget his reading and writing time on each frame. In addition, audio instruction was provided indicating when Ss should stop writing and attend to the confirmation frame when it appeared. Since the fully prompted condition required only that S copy the responses provided, no confirmation frames were necessary in the four fully prompted versions.

At the conclusion of the Elasticity program, Ss were instructed to close their response booklets and were given the Immediate Posttest.

Upon completion of the test, booklets were re-opened and an identical procedure was followed for the presentation of the Relationships program and Posttest.

Twenty-six or twenty-seven days following the televised lessons, the posttests were readministered to the Ss in their classrooms to serve as a retention measure.

RESULTS

The data from this experiment are treated in four separate analyses. Each analysis was performed on data from a differently constituted group or sub-group so as to provide evidence on a somewhat different issue. The first analysis was based upon the sample of all 252 participating Ss, non-qualifiers as well as qualifiers. This made it possible to obtain the most powerful assessment of the effects of the Tempo and Prompting variables across all ability levels. A second analysis was performed on a sample of 96 Ss who were selected from the total sample of qualifiers only. These Ss were matched for Work Rate and IQ so as to prevent their confounding and to permit a levels analysis involving these variables. The second analysis thus assessed the main effects due to Tempo and Prompting as well as the interactions among these experimentally manipulated variables and the individual difference variables. A third analysis was performed on only the 32 Ss who participated in the Non-Prompted condition. This analysis was designed to assess the relationships among Tempo, Work Rate, and IQ, independent of the "prompting" variable. Finally, a group of 144 Ss was selected so as to obtain a maximally sensitive estimate of the interactive effects of Work Rate and the experimental variables Prompting and Tempo.

The Effects of Prompting and Tempo

In order to study the effects of Prompting and Tempo on student performance, an analysis was made for the results for the total of 252 Ss who participated in the study. Using this entire sample resulted in 21 replicates in each of the 12 cells of the basic design (4 levels of Tempo x 3 levels of Prompting). Through random assignment of Ss to experimental conditions, IQ and Work Rate were equated across all 12 conditions. No significant differences, as revealed by an analysis of variance, were found among these conditions for either variable. (These analyses as well as the IQ and Work Rate means and S.D.s for each condition are summarized in Tables 1 through 3 in Appendix B.) The effects of Tempo and Prompting could thus be assessed with both IQ and Work Rate controlled.

The group of 252 Ss taken in its entirety included the full range of abilities and work rates encountered in the classes sampled and included both qualifiers and non-qualifiers. This total group, then, was taken to be the best sample available on which to observe the effects of Tempo and Prompting on performance across all ability and work rate levels.

Since no systematic attempt was made to equate groups on the basis of Pretest scores on either the Elasticity or Relationships program, and since this variable was found to be related to achievement scores, Pretest scores were employed as a covariate in all analyses. The results to follow will therefore be those obtained by means of covariance analysis.

The dependent measures of interest in this experiment are scores on the Immediate Posttest and Retention Test as well as the number of Errors committed in each program. The six analyses of covariance performed for these measures are summarized, together, in Table 2 for ease of comparison.

(a) prompting. - By design, errors were not expected to occur in the fully-prompted condition. Accordingly, in the analysis of how Prompting levels affected Errors, data from the fully-prompted condition were omitted. As shown in Table 2, there were significant differences between the remaining two Prompting conditions ($P<.001$). Error rates on the Elasticity program declined from 33 percent for the non-prompted condition to 23 percent for the partially-prompted condition. In the case of the Relationships program, the decline was from 21 to 12 percent. Tables 3 and 4, appearing on page 18, present the mean number of errors under each of the two prompting conditions. Thus, as will be shown below, whereas increases in Tempo led to increases in error rates, increases in the degree of prompting led to decreases in error rates.

Despite the fact that increases in the degree of prompting led to lower error rates, achievement scores, as can be seen from an inspection of Tables 5 through 8 on page 18, were either unaffected or significantly depressed. The decrease in achievement from non-prompted to fully-prompted conditions was significant for both the Immediate Relationships Posttest and for the Elasticity Retention Test. (See Table 2.) Thus, even though the additional prompts significantly reduced errors, they also tended to depress achievement.

Table 2

Summaries of Six Covariance Analyses
Based Upon the Total Sample[1,2,3]
(N = 256)

	SOURCE	D.F.	MEAN SQUARES	F
ERRORS ELASTICITY	A Tempo	3	1.307	20.93***
	B Prompting	1	.766	12.26***
	AB Tempo x Prompting	3	.036	-
	Within	159	.062	
ERRORS RELATIONSHIPS	A Tempo	3	2.318	22.52***
	B Prompting	1	1.661	16.14***
	AB Tempo x Prompting	3	.016	-
	Within	159	.103	
POSTTEST ELASTICITY	A Tempo	3	169.666	-
	B Prompting	2	1322.015	1.26
	AB Tempo x Prompting	6	527.304	-
	Within	239	1051.113	
POSTTEST RELATIONSHIPS	A Tempo	3	6707.743	3.60**
	B Prompting	2	14153.756	7.60***
	AB Tempo x Prompting	6	817.030	-
	Within	239	1863.656	
RETENTION ELASTICITY	A Tempo	3	292.841	-
	B Prompting	2	3613.002	3.17*
	AB Tempo x Prompting	6	584.958	-
	Within	239	1140.922	
RETENTION RELATIONSHIPS	A Tempo	3	1909.474	1.11
	B Prompting	2	2349.906	1.36
	AB Tempo x Prompting	6	3659.555	2.12
	Within	239	1725.087	

*significant beyond the .05 level
**significant beyond the .01 level
***significant beyond the .001 level

[1] Since the fully-prompted conditions allowed no errors to occur, they were excluded from the Error analyses, reducing the N for these analyses to 168 and degrees of freedom for the prompting variable to 1.

[2] Error scores were transformed by the formula: $X^1 = \log(X+1)$.

[3] Pretest scores were used as the covariate in all analyses.

Table 3

Mean Number of Errors for
Each Level of Tempo and Prompting
Elasticity Program[1,2]
(N = 168)

LEVELS OF INDEPENDENT VARIABLES		MEAN
TEMPO	Base	14.28
	Base -1	18.51
	Base -2	25.45
	Base -3	30.96
PROMPTING	Non-Prompted	26.13
	Extra Prompts	18.48

Total number of errors possible = 79.

Table 4

Mean Number of Errors for
Each Level of Tempo and Prompting
Relationships Program[1,2]
(N = 168)

LEVELS OF INDEPENDENT VARIABLES		MEAN
TEMPO	Base	8.31
	Base -1	13.70
	Base -2	17.27
	Base -3	20.67
PROMPTING	Non-Prompted	18.98
	Extra Prompts	10.99

Total number of errors possible = 89.

Table 5

Means of Immediate Posttest Scores for
Each Level of Tempo and Prompting
Elasticity Program[1]
(N = 252)

LEVELS OF INDEPENDENT VARIABLES		MEAN
TEMPO	Base	9.95
	Base -1	9.75
	Base -2	10.01
	Base -3	9.66
PROMPTING	Non-Prompted	9.97
	Extra Prompts	10.15
	Fully-Prompted	9.41

Total test score possible = 15 points.

Table 6

Means of Immediate Posttest Scores for
Each Level of Tempo and Prompting
Relationships Program[1]
(N = 252)

LEVELS OF INDEPENDENT VARIABLES		MEAN
TEMPO	Base	13.41
	Base -1	12.99
	Base -2	12.87
	Base -3	11.15
PROMPTING	Non-Prompted	14.10
	Extra Prompts	11.69
	Fully-Prompted	12.03

Total test score possible = 19 points.

Table 7

Means of Retention Test Scores for
Each Level of Tempo and Prompting
Elasticity Program[1]
(N = 252)

LEVELS OF INDEPENDENT VARIABLES		MEAN
TEMPO	Base	8.88
	Base -1	9.06
	Base -2	8.97
	Base -3	8.52
PROMPTING	Non-Prompted	9.61
	Extra Prompts	8.58
	Fully-Prompted	8.39

Total test score possible = 15 points.

Table 8

Means of Retention Test Scores for
Each Level of Tempo and Prompting
Relationships Program[1]
(N = 252)

LEVELS OF INDEPENDENT VARIABLES		MEAN
TEMPO	Base	8.28
	Base -1	7.45
	Base -2	7.55
	Base -3	7.18
PROMPTING	Non-Prompted	7.79
	Extra Prompts	6.98
	Fully-Prompted	8.09

Total test score possible = 19 points.

[1] Adjusted for Pretest scores.

[2] Analyses were performed using error scores transformed by the formula: $X^1 = \log(X+1)$.

(b) tempo. - The effect on Errors of the successive increments in Tempo was consistent with that observed in the initial experiment in this series (Kress & Gropper, 1964b). As Tempo increased, the number of errors also increased. Inspection of means in Tables 3 and 4 indicates that this uniform relation was found for both programs. Expressed as a ratio of the total number of errors possible, the average error rates on the Elasticity program increased from 18 percent at the slowest Tempo to 39 percent for the fastest Tempo. The corresponding results for the Relationships program reveal an increase in error rates from 9 to 23 percent. As shown in the first part of Table 2, differences in Errors between Tempo levels were significant ($P < .001$).

Analyses based on Immediate Posttest and on Retention tests reveal trends supportive of, but by no means as clear-cut or as regular as those found for error data.

As might be expected on the basis of theoretical notions about the inverse relationship between errors and achievement, results for the Relationships program, to be found in Tables 5 and 7, show that, unlike error scores which became larger as Tempo became faster, achievement scores declined with increases in Tempo. On the Immediate Posttest, differences among the four Tempo levels were statistically significant ($P < .05$) with means (expressed as percentages of total possible number of test points) declining from 71 percent for the slowest tempo to 59 percent for the fastest tempo. A similar, though non-significant, trend was found for the Retention test. Achievement results for the Elasticity program, to be found in Tables 6 and 9, reveal no consistent or statistically significant trend. It will be noted, however, that means for the fastest tempo on both the Immediate test and on the Retention test were the lowest of all the Tempo levels. Thus, unlike increases in Prompting strength which led to lower errors and lower achievement, increases in Tempo levels led to higher errors and generally to lower achievement.

No significant interaction was observed between the Tempo and Prompting variables on any of the dependent measures.

The effects of Tempo were analyzed further using only data from the Non-Prompted condition. The decision to perform such an analysis was based on these considerations: (a) there were significant differences among the three prompting conditions; (b) there was no significant interaction between Tempo and Prompting; (c) the Non-Prompted condition generally led to the highest mean achievement scores and was likely to continue to constitute the most representative form in which programmed instruction would be offered (whether under self-paced or fixed-paced conditions); and (d) it also appeared desirable to assess interactive effects of Tempo with Work Rate and IQ,using only qualifiers (i.e.,those who achieved at a pre-determined level on the self-paced programs administered before the main experimental comparison under fixed-paced conditions).

Using data for the 32 matched Ss who were in the Non-Prompted condition, an analysis of covariance, with pre-test as the covariate, was performed for each of the three dependent measures: Errors, Immediate Posttest scores, and Retention Test scores. Since IQ and Work Rate are correlated variables, these Ss were matched on the basis of both Work Rate and IQ resulting in high/low IQ groups and in fast/slow Work Rate groups. High and low IQ groups, because of the matching procedure, did not differ significantly on Work Rate. Nor did the fast and slow workers differ significantly on IQ. (Results of an analysis of variance showing the independence of these two variables can be found in Tables 4 to 6 in Appendix B.)

For the purpose of analyzing the effects of Tempo under Non-Prompted conditions only, the four levels of Tempo were collapsed into two, with Tempos B and B -1 combined and Tempos B -2 and B -3 combined. This resulted in a 2x2x2 factorial design: two levels of Tempo, two levels of IQ and two levels of Work Rate.

The effect on Errors which resulted from increasing Tempo levels paralleled that found across all prompting conditions. As shown in Tables 9 and 10, significant increases in Errors occurred with increases in Tempo ($P<.01$). The mean number of Errors on both the Elasticity and Relationship programs for each Tempo level are shown in Tables 11 and 12 appearing on page 23. Expressed as ratios of total number of Errors possible,

Table 9

Summary of the Covariance Analysis for Log Errors on the Elasticity Program, Using the 32 Ss in the Non-Prompted Condition Only[1]

Source of Variation	D.F.	Mean Squares	F
A - Tempo	1	1.23	11.12**
B - Work Rate	1	.04	-
C - IQ	1	..15	1.36
AB	1	.07	-
AC	1	.04	-
BC	1	.01	-
ABC	1	.00	-
Within	23	.11	

**significant beyond the .01 level.

Table 10

Summary of the Covariance Analysis for Log Errors on the Relationships Program, Using the 32 Ss in the Non-Prompted Condition Only[1]

Source of Variation	D.F.	Mean Squares	F
A - Tempo	1	2.57	12.13**
B - Work Rate	1	.01	-
C - IQ	1	.43	2.04
AB	1	.64	3.04
AC	1	.08	-
BC	1	.01	-
ABC	1	.02	-
Within	23	.21	

**significant beyond the .01 level.

[1]Pretest scores were used as the covariate.

error rates increased from 20 to 37 percent on the Elasticity program and from 8 to 20 percent on the Relationships program. Achievement data, as shown in Tables 13 to 20, reveal no significant differences between slow and fast tempos, although on both immediate and retention tests for both programs, higher mean achievement scores resulted under the slow condition. These results were similar to those found in the first analysis, except that those achievement test results did show some differences which were significant.

The role of IQ and Work Rate in these and subsequent analyses will be discussed in sections which follow.

The Role of IQ and Work Rate

Analyses based on results for the 32 Ss in the Non-Prompted condition revealed neither consistent nor reliable main effects due to either IQ or Work Rate. In only one analysis, that of Retention scores for the Elasticity program, did high IQ Ss have significantly higher scores than the low IQ Ss. As to Work Rate results, no significant differences at all were found between characteristically fast and slow Ss.

To obtain a further estimate of the role these variables might play across all tempo and all prompting conditions, an analysis was performed based on a sample of 96 Ss drawn from the total sample. Subjects who had qualified on preliminary self-paced programs were matched for IQ and Work rate so that high and low IQ Ss did not differ significantly on work rate. Nor did fast and slow Ss differ significantly on IQ (see Tables 7 to 9 in Appendix B).

Tables 10 to 21, also in Appendix B, summarize the analyses based on the sample of 96 Ss. Of the six measures obtained (three dependent measures for each of the two programs), three showed significant differences, with the high IQ Ss outperforming the low IQ S. Differences in the same direction, though not significant, were also found for the remaining three measures. In this analysis based on 96 Ss, Work Rate, once again, failed to produce a significant difference on any of the six measures.

Table 11
Mean Number of Errors on the Elasticity Program[1]
(N = 32)

LEVELS OF INDEPENDENT VARIABLES		MEAN
TEMPO	Slow	15.74
	Fast	29.12
WORK RATE	Fast	19.25
	Slow	25.51
IQ	High	22.48
	Low	22.29

Table 12
Mean Number of Errors on the Relationships Program[1]
(N = 32)

LEVELS OF INDEPENDENT VARIABLES		MEAN
TEMPO	Slow	7.04
	Fast	18.23
WORK RATE	Fast	10.08
	Slow	15.18
IQ	High	11.59
	Low	13.67

Table 13
Means of Immediate Posttest Scores Elasticity Program[1]
(N = 32)

LEVELS OF INDEPENDENT VARIABLES		MEAN
TEMPO	Slow	11.46
	Fast	10.26
WORK RATE	Fast	10.59
	Slow	11.13
IQ	High	11.05
	Low	10.21

Table 14
Means of Immediate Posttest Scores Relationships Program[1]
(N = 32)

LEVELS OF INDEPENDENT VARIABLES		MEAN
TEMPO	Slow	16.96
	Fast	15.42
WORK RATE	Fast	16.47
	Slow	15.90
IQ	High	16.65
	Low	15.72

Table 15
Means of Retention Test Scores Elasticity Program[1]
(N = 32)

LEVELS OF INDEPENDENT VARIABLES		MEAN
TEMPO	Slow	11.06
	Fast	10.63
WORK RATE	Fast	11.09
	Slow	10.59
IQ	High	12.31
	Low	9.38

Table 16
Means of Retention Test Scores Relationships Program[1]
(N = 32)

LEVELS OF INDEPENDENT VARIABLES		MEAN
TEMPO	Slow	9.77
	Fast	9.22
WORK RATE	Fast	9.46
	Slow	9.53
IQ	High	10.07
	Low	8.92

[1] Adjusted for Pretest scores.

Table 17

Summary of the Covariance Analysis for Immediate Posttest Scores on the Elasticity Program, Using the 32 Ss in the Non-Prompted Condition Only[1]

Source of Variation	D.F.	Mean Squares	F
A - Tempo	1	1163.31	1.15
B - Work Rate	1	249.52	-
C - IQ	1	125.26	-
AB	1	98.77	-
AC	1	1078.32	1.07
BC	1	2263.29	2.24
ABC	1	378.54	-
Within	23	1011.75	

Table 18

Summary of the Covariance Analysis for Immediate Posttest Scores on the Relationships Program, Using the 32 Ss in the Non-Prompted Condition Only[1]

Source of Variation	D.F.	Mean Squares	F
A - Tempo	1	1885.30	1.66
B - Work Rate	1	265.65	-
C - IQ	1	786.48	-
AB	1	5.80	-
AC	1	1767.86	1.55
BC	1	379.42	-
ABC	1	407.33	-
Within	23	1138.89	

[1] Pretest scores were used as the covariate.

Table 19

Summary of the Covariance Analysis for Retention Scores on the Elasticity Program, Using the 32 Ss in the Non-Prompted Condition Only[1]

Source of Variation	D.F.	Mean Squares	F
A - Tempo	1	143.29	-
B - Work Rate	1	154.76	-
C - IQ	1	6090.02	12.49**
AB	1	1739.20	3.57
AC	1	17.71	-
BC	1	2509.58	5.15*
ABC	1	47.64	-
Within	23	487.58	

*significant beyond the .05 level
**significant beyond the .01 level

Table 20

Summary of the Covariance Analysis for Retention Scores on the Relationships Program, Using the 32 Ss in the Non-Prompted Condition Only[1]

Source of Variation	D.F.	Mean Squares	F
A - Tempo	1	245.01	-
B - Work Rate	1	2.83	-
C - IQ	1	1210.43	-
AB	1	8626.89	6.53*
AC	1	3253.30	2.46
BC	1	2025.34	1.53
ABC	1	212.95	-
Within	23	1321.43	

*significant beyond the .05 level

[1]Pretest scores were used as the covariate.

Interaction Between Tempo and Work Rate

In the various analyses described thus far, no main effects attributable to Work Rate were observed. There was, however, a fairly consistent interactive trend which appeared in several analyses. Interactions were observed between Tempo and Work Rate. To obtain a more sensitive estimate of this interactive effect, one final analysis was performed to study the main and interactive effects of Tempo, Prompting, and Work Rate. A sample of 144 qualifying Ss was selected. The sample included Ss more extreme on the Work Rate dimension, both faster and slower, than was the case in earlier analyses. A double covariance analysis was performed with IQ and pretest treated as covariates. (The results of this analysis are summarized in Tables 22 to 33 in Appendix B.) While the interaction between tempo and work rate was significant only in the analysis of retention scores for the Relationships program ($P<.05$), similar trends were observed on four out of five of the remaining analyses. The consistency of this trend in this analysis and its appearance on prior analyses merit further attention.

Subjects who were characteristically fast under self-paced conditions out-performed the characteristically slow Ss when both performed under the fast, fixed tempo condition. This difference between fast and slow Ss was found on all six analyses (three dependent measures for each of the two programs). This finding can be seen in Fig. 8 to 13 for these six analyses.

Quite surprisingly, however, in five out of six analyses, the opposite effect was observed for the slow, fixed tempo. Characteristically fast workers (under self-paced conditions) made more errors and achieved lower scores than slower workers when both worked under slow fixed tempo conditions. Thus, even though fast workers were statistically matched with slow workers for ability, under the slow fixed tempo, where impairment would not be expected to be high for either group, fast workers did more poorly.

Miscellaneous Findings

Other interactions were observed in the several analyses. However, unlike the tempo x work rate interaction, only isolated, significant results were found, with no consistent trends in other analyses to support them.

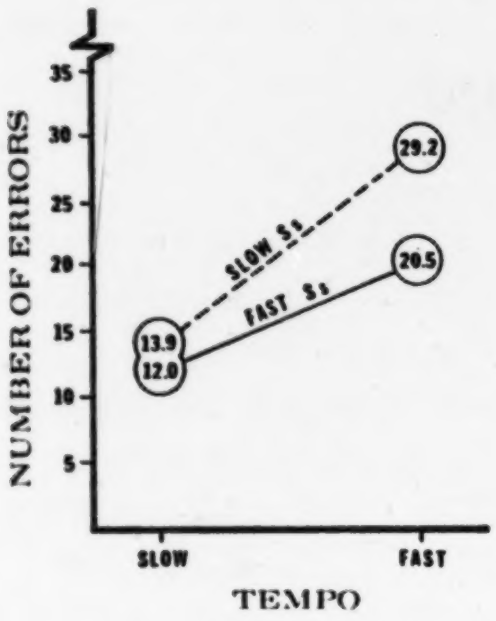


Figure 8

Interactive Effect of External Tempo and Characteristic Work Rate on ERRORS (Elasticity Program)

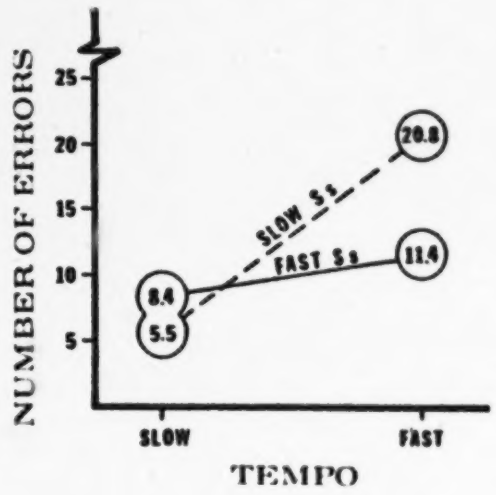


Figure 9

Interactive Effect of External Tempo and Characteristic Work Rate on ERRORS (Relationships Program)

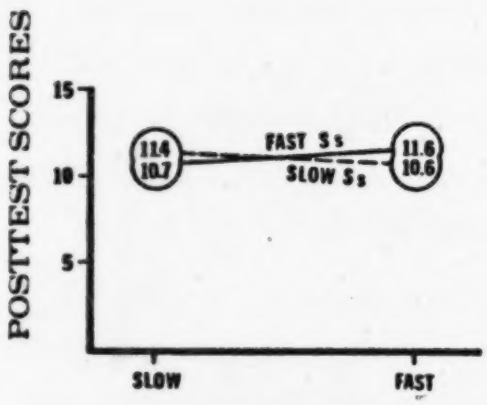


Figure 10

Interactive Effect of External Tempo and Characteristic Work Rate on POSTTEST Scores (Elasticity Program)

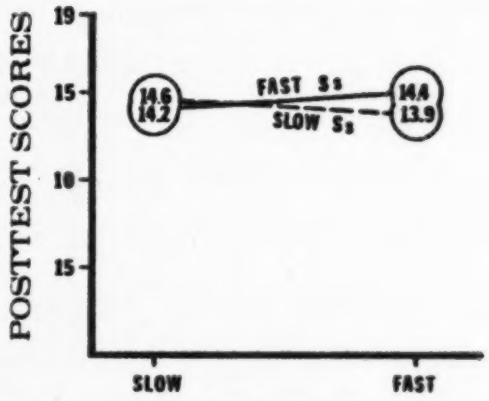


Figure 11

Interactive Effect of External Tempo and Characteristic Work Rate on POSTTEST Scores (Relationships Program)

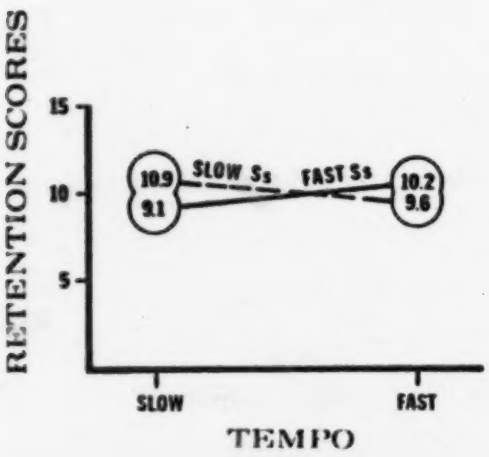


Figure 12

Interactive Effect of External Tempo and Characteristic Work Rate on RETENTION Scores (Elasticity Program)

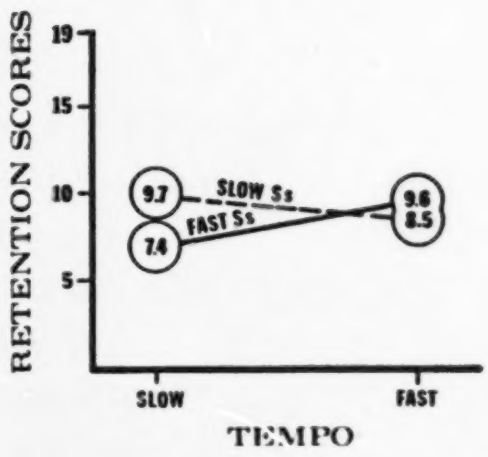


Figure 13

Interactive Effect of External Tempo and Characteristic Work Rate on RETENTION Scores (Relationships Program)

DISCUSSION

It is both theoretically and practically possible to select a presentation pace that can be slow enough so that even a group heterogeneous with respect to ability or pacing requirements can be accommodated. Indeed, the evidence presented in report #2 (Kress & Gropper, 1964b) in this series has shown that a slow, fixed pace can even produce results superior to those made possible through self-pacing. But there, as might be expected, the fixed pace which was slow enough to accommodate most Ss in the group represented for many of the group a use of time which was inefficient. Thus, the question is not whether students can learn effectively under fixed-paced conditions, for it has been demonstrated that they can. Rather, the question is, is it possible for them to learn both effectively and efficiently. For fixed-paced group instruction to be capable of meeting this dual objective seems to call for greater "individualization." Some means must be found to allow the use of tempos faster and more efficient than the slow fixed-tempo which appears to be required if an entire, heterogeneous group is to be accommodated.

This experiment has brought under scrutiny two possible strategies for accommodating individual differences under fixed-paced conditions. Both strategies involved methods for aiding a heterogeneous group of eighth grade Ss to learn effectively and efficiently under fixed tempos. The study has, on the one hand, sought to determine whether increased student guidance in the form of added prompting could help characteristically slow students to resist the expected detrimental effect that increases in tempo is known to have. If added prompting can produce appropriate compensations, then students differing in pacing requirements might still be accommodated even though a single, faster, and hence more efficient program was presented to them. The second strategy for accommodating differences in pacing requirements would consist of separate program sources. A strategy of separate program sources might be capable of providing, for those who need it, tempos slow enough to be compatible with effective learning and, for those who do not, faster tempos compatible with efficient learning. The findings of this study tend to suggest the need for the second of these two strategies.

The Strategy of Added Prompting

Increasing tempos in effect reduces stimulus exposure durations. The cuing or prompting value of stimulus materials is thereby reduced, as shown by increases in errors. The added physical prompts used in this study served to increase the cue-value of stimulus materials, as can be seen from the resulting reduction in errors. But this increase in cue-value across all tempo conditions, was not accompanied by an improvement in achievement. On the contrary, achievement results tended to decline as the degree of prompting increased. Tests based on two of the four achievement measures obtained indicated that the decline was statistically significant.

The non-prompted condition had produced the greatest number of errors. Surprisingly enough, in view of the known, moderately high negative relationship between errors and achievement (Kress & Gropper, 1964a), the same condition produced the highest achievement levels. These findings suggest the superiority of non-prompted response-practice, with errors, over fully-prompted response-practice, with few or no errors. The findings, it should be pointed out, are not in keeping with those reported by Della-Piana (1961), Evans, Glaser, and Homme (1960), and Goldbeck, Campbell, and Llewellen (1960) who investigated response modes in self-paced programmed instruction. They reported that, if programs are well revised, reading responses are more efficient than constructed responses. The discrepancy between those studies and the present one may in part be explained by the fact that fixed tempos were employed in the present study creating more difficult learning conditions than was likely to be the case in earlier studies which allowed students to pace themselves. If responding under fixed-tempo conditions, particularly faster tempos, can be construed to constitute difficult learning conditions, then these findings are, it is suggested, in keeping with findings that "overt" practice (non-fully prompted responding) is superior when the material to be learned is relatively difficult (Goldbeck & Campbell, 1962). They are also in keeping with the Angell and Lumsdaine (1962) findings that retention results in their study were superior for groups which learned from programmed materials in which cues were vanished.

Generally, it would appear that extra prompting, across all tempo conditions, resulted in poorer rather than improved student performance. Moreover, added prompting showed no significant or uniform, differential results for either fast or slow fixed-tempo conditions. In view of these findings, it would appear that, while added cuing does reduce error frequencies, it also alters the character of the learning experience sufficiently so that achievement is impaired rather than improved. Since achievement is the ultimate criterion of instructional effectiveness, prompting variations do not appear capable of offsetting the across-the-board impairment created by increases in tempo. Therefore, as a strategy for accommodating individual differences in fixed-paced instruction, a single program source with added prompting does not appear indicated.

The Strategy of Separate Program Sources

The present study did not offer alternative program sources to different, homogeneously constituted groups. It did however compare the performance of characteristically fast and slow workers (as determined under self-paced conditions) under different, externally controlled tempo conditions. The interactions observed between characteristic work rates and externally controlled tempos were not uniformly significant. However, the trends observed were uniform and are moderately persuasive. They suggest the possibility that greater individualization of instruction might be attained by creating homogeneous groupings presented with tempos tailored to their needs.

Students who characteristically adopt a fast pace under self-paced conditions and who demonstrate that they can achieve at such a pace appear to learn more under a fast than under a slow fixed-tempo. Any impairment created by a fast fixed-tempo is more likely to be felt by the characteristically slow students. Under the fast fixed-tempo, the slow workers achieve less than their characteristically fast counterparts with whom they have been matched for IQ. The reason that slow students achieve less than their fast counterparts is likely to be that fast fixed-tempos provide them with stimulus exposure durations shorter than those they are accustomed to. Whatever their characteristically slow work rate is due to, reading speed or work habits or both, the stimulus exposure durations of a fast fixed tempo are

less likely to be sufficient to cue correct responding. Under the fast fixed-tempo, slow students do exhibit a higher error rate and also tend to achieve less than their fast counterparts. Test results are also lower for slow students than for their slow counterparts who perform under the slow fixed-tempo condition. Thus, it appears that students who habitually and successfully (in terms of achievement) adopt a fast pace under self-paced conditions, when exposed to externally-set fast tempos, can adapt to them. Those who characteristically adopt a slow pace under self-paced conditions, when exposed to identical, externally-set fast tempos, adapt less well. Thus, despite the fact that efficiency may suffer, it may be important to allow characteristically slow students to work under a slow fixed-tempo condition.

Under slow fixed tempos, the results are surprisingly the converse. If characteristically fast students can adapt to a fast fixed-tempo, they would not be expected to have their performance particularly impaired under a slow fixed tempo. However, under the slow fixed-tempo condition, the characteristically fast students actually performed more poorly than the characteristically slow students working under the same condition. Moreover, the characteristically fast students in the slow fixed-tempo condition generally produced achievement results inferior to that of their characteristically fast counterparts working in the fast fixed-tempo condition. Since IQ was controlled in both these comparisons, these findings suggest that it was not ability to learn which was operative in producing these results.

A number of alternative explanations suggest themselves. Students who work at a fast pace were likely, under the slow fixed-tempo condition, to have completed each frame presented to them before its total exposure duration elapsed. This may have provided more opportunity for the practice of competing responses. Also, the interval between response and confirmation was longer for fast students than for slow students. While this study was not designed to measure motivation or attitude, these findings also suggest the possibility that characteristically fast students may have been bored by the slow fixed-tempo condition. Whatever the explanation, it appears that the detrimental effects of inappropriate fixed pacing are not restricted to those characteristically slow students who are forced to work too rapidly. Too slow a pace for characteristically fast students, in addition to being inefficient, also leads to lowered

learning effectiveness. It may be important, therefore, to assign characteristically fast students to a separate, fast condition tailored more closely to their pacing needs.

It is suggested in report #1 (Kress & Gropper, 1964a) that some students require slowing down. The evidence from that report suggested that below average students who adopt fast work rates and who fail to reach predetermined performance levels, might be candidates for such treatment. The "fast" students who were required to work under slow fixed-tempo conditions in the present study tended to do more poorly (in terms of achievement) than their "slow" counterparts under the same condition and more poorly than their "fast" counterparts under the fast fixed-tempo condition. The "fasts" included students who were both above and below average in ability. Since no significant tempo, work rate, and IQ interactions were observed, it is difficult to assess, which "fasts" might be successfully slowed down and which might not. However, it should be pointed out that the present study included only qualifiers (students who did achieve satisfactorily under self-paced conditions). Therefore, the "fasts" included here were, so to speak, true "fasts." Slowing them down had detrimental effects. Any study to determine whether non-adaptive "fasts" can be successfully slowed down must include non-qualifiers. The number of non-qualifiers included in the present study was insufficient to determine whether non-adaptive "fasts" can be successfully slowed down.

A further suggestion made in the first two reports of this series was that slow, but bright students who attain satisfactory achievement levels under self-paced conditions might be speeded up in the interest of greater learning efficiency. Screening procedures might be necessary, however, to determine which students, if any, might be successfully speeded up. The results of the present study revealed, in general, that characteristically slow students did more poorly under fast fixed-tempos than their matched, slow counterparts did under slow fixed-tempos. The "slows" represented students at all ability levels. Since no uniform IQ interactions were observed, it is difficult to determine whether some slow students might be more successfully speeded up than others.

The results of the present study, in general, suggest that characteristically slow students, for whom the slow pace is adaptive, may not be successfully speeded up without impairing their level of achievement.

However, it must be remembered that the fast tempo employed in this study was not tailored to the needs of a particular group which was to be speeded up. It was, in fact, not tailored to any particular group. Based on the results of this study, it remains open to question whether a single, fast fixed-tempo can be tailored so that it is suitable for characteristically fast students and for characteristically slow students who can be speeded up. It might be possible to identify a subgroup of slow students whose efficiency can be improved at no cost in achievement. Such identification, if possible, would require a more analytic examination of a larger sample of characteristically slow, high achievers. A compromise "fast" tempo delivered to such a subgroup, combined with fast workers, as long as it is not perceived as being slow by the characteristically fast students, would still be more efficient than either a self-adopted or an externally selected slow tempo. Whether such a compromise is possible remains an empirical problem.

While these considerations have been offered in part as remedies for students who in self-paced instruction adopt non-adaptive paces, they appear relevant to presentations which must of necessity be fixed-paced. Filmed or televised demonstrations are fixed-paced in character, and these pacing considerations are equally applicable to them as they are to verbal, printed presentations. If these types of presentations are to be individualized, separate program sources appear indicated with assignment to a particular source perhaps best made on the basis of the individual student's characteristic work rate adopted under self-paced conditions.

CONCLUSION

The ideal outcome of individualized instruction is both effective and efficient instruction. Confining ourselves to a consideration of fixed-paced instruction which is offered because the medium required happens to be fixed-paced in character, how can such instruction be both effective and efficient? When slow, it tends to be effective but inefficient for slow workers. Unless it can be demonstrated which slow students, if any, can be speeded up, inefficiency may be the price that must be paid to make effectiveness possible. The trade-off is no different than that which is currently necessary in self-paced instruction. Since fast workers appear to be capable of tolerating fast tempos, slow fixed-tempos would be even more inefficient for them. For fast workers, slow fixed-tempo instruction also appears to be ineffective. Thus, when fixed-paced instruction is fast, it is appropriately effective and efficient for fast workers. For slow workers it is considerably less effective and, as a result, its efficiency is of little concern to us.

These findings suggest that when fixed-paced presentations are offered in group settings, optimal effectiveness and efficiency can only be attained by offering more than one program source, with each program source tailored to the needs of groups of students who share pacing requirements. While this study was not designed to determine how many such program sources might be necessary, it is not unreasonable to speculate, based on the achievement levels found here, that two program sources might fill the needs even of a group relatively heterogeneous in pacing requirements. For this purpose, it might be pointed out, the level of effort required to prepare alternative tempo presentations of the same lesson, relative to that required for initial program development, is quite small.

It has been shown that self-pacing can be non-adaptive (Kress & Gropper, 1964a), and that, under some circumstances, instruction can be more effective when it is fixed-paced rather than self-paced (Kress & Gropper, 1964b). Thus, it seems clear that the best evidence as to whether individualization has been achieved, comes not from an inspection of

independent variables, i.e., how many separate or individual treatments students are provided. Paradoxically, it does come from an inspection of dependent measures indicating how effective and efficient learning has been. Thus, while a small number of fixed-paced program sources does not, at least as far as numbers of separate "treatments" go, begin to approach the degree of individualization provided when students pace themselves, it can nevertheless be said to have resulted in individualization if it has made learning effectiveness or efficiency possible for an entire group. Stated this way, it becomes an empirical matter. The evidence from separate studies in this series suggests that "individualization" can occur even when student work pace is not individually selected.

REFERENCES

1. Alter, Millicent & Silverman, R. E. The response in programed instruction. J. programed Instruct., 1963, 1, 55-77.

2. Angell, D. & Lumsdaine, A. A. Retention of material presented by autoinstructional materials which vanish and which do not vanish verbal cues. San Mateo, Calif.: American Institutes for Research, 1962.

3. Cook, J. O. & Spitzer, M. E. Supplementary report: Prompting versus confirmation in paired-associate learning. J. educ. Psychol., 1960, 59, 275-276.

4. Della-Piana, G. M. An experimental evaluation of programmed learning: Motivational characteristics of the learner, his responses, and certain learning outcomes. Salt Lake City: Univer. of Utah, December 1961.

5. Evans, J. L., Glaser, R & Homme, L. E. An investigation of "teaching machine" variables using learning programs in symbolic logic. Pittsburgh: University of Pittsburgh, December 1960.

6. Goldbeck, R. A. & Campbell, V. N. The effects of response mode and response difficulty on programmed learning. J. educ. Psychol., 1962, 53, 110-118.

7. Goldbeck, R. A., Campbell, V. N., & Llewellyn, Joan E. Further experimental evidence on response modes in automated instruction. Santa Barbara, Calif.: American Institutes for Research, December 1960. (Technical Report No. 3)

8. Kress, G. C., Jr. & Gropper, G. L. Individual differences in learning from self-paced programmed instruction - Report #1. Studies in televised instruction: Individualizing group instruction. Pittsburgh: American Institutes for Research, 1964. (a)

9. Kress, G. C., Jr. & Gropper, G. L. The influence of external pacing on learning from programmed instruction - Report #2. Studies in televised instruction: Individualizing group instruction. Pittsburgh: American Institutes for Research, 1964. (b)

APPENDIX A

Programmed Materials and Tests

Page

1. Experimental Programs
   - A. Elasticity program A-1
   - B. Relationships program. A-5

2. Achievement Tests
   - A. Elasticity test A-10
   - B. Relationships test. A-12

ELASTICITY PROGRAM*

DEMONSTRATION 1

Three examples were shown of objects changing in shape: a rod was bent, a rubber ball was flattened, and a spring was stretched.

1.

A sag in a mattress is an example of a change in the shape of the mattress. A dent in a fender is an example of a CHANGE in the SHAPE of the fender.

2.

When we push down on a metal strip it bends. The bending is an example of a CHANGE in the SHAPE of the METAL STRIP.

3.

If you squash a rubber ball in your hand, the flattening of the ball is an example of a CHANGE in the SHAPE of the RUBBER BALL.

4.

Any time you apply a force to objects and they either bend, flatten out, get rounder, or stretch, we would say that THEIR SHAPE HAS CHANGED.

5.

If you push down on a round balloon, the shape of the balloon will change. The balloon will become FLATTER.

6.

If heavy clothes are hung on a clothesline, the shape of the line will change. The clothesline will change from being straight to being CURVED.

7.

A change in the shape of a rubber ball is caused by a force which is applied to the ball. A change in the shape of a mattress is CAUSED by a FORCE which is APPLIED to the MATTRESS.

8.

A bend in a clothesline can be CAUSED by a FORCE which is applied to the CLOTHESLINE.

9.

When the shape of any object changes, the change is CAUSED by the FORCE which is applied to the OBJECT.

10.

A dent in an automobile fender is caused by a FORCE WHICH IS APPLIED TO IT.

11.

There is a special word for the change in the shape of objects. It is called a strain. A dent in an automobile fender is called a STRAIN.

*Included among the frames is a brief description of each demonstration at the point at which it occurred in the television lessons. The frames presented here correspond to: (1) the Fully Prompted version of the lesson, and (2) the form employed as confirmation frames in the other versions.

12.

The sag in a mattress when we sit on it is called a STRAIN.

13.

The stretching of a spring when we pull it is called a STRAIN.

14.

A strain is a change in the shape of an object caused by a force. The dent in a fender is called a strain because it is a CHANGE in the SHAPE of the fender caused by a FORCE.

15.

When we squash a ball, the flattening of the ball would be called a strain because the flattening is a CHANGE in the SHAPE of the BALL which is caused by a FORCE.

16.

When you sit on a cushion and make it sag, the sag in the cushion is a strain because it is a CHANGE in the SHAPE of the cushion which is CAUSED by a FORCE.

17.

When shooting an arrow, the bend in the bow would be called a strain because it is a CHANGE in the SHAPE of the bow which is CAUSED by a FORCE.

18.

We use the word strain to describe any CHANGE IN THE SHAPE OF OBJECTS CAUSED BY A FORCE.

19.

Pulling a spring causes a strain in the spring. Sitting on a cushion causes a STRAIN IN THE CUSHION.

20.

If you jump on a trampoline, the force due to your jump will cause a STRAIN ON THE TRAMPOLINE.

21.

The force applied by your hand when squashing a ball is called a stress. The force which causes a strain is called a STRESS.

22.

The pulling force which causes a spring to stretch out is called a STRESS.

23.

The force which dents a fender is called a STRESS.

24.

Any force which causes a strain in an object is called a stress. A pull on a spring is called a stress because it is a FORCE which CAUSES a STRAIN in the spring.

25.

When you sit on a cushion, your weight pushing down is a stress because it is a FORCE which CAUSES A STRAIN in the CUSHION.

26.

The word stress is used to describe any FORCE WHICH CAUSES A STRAIN IN AN OBJECT.

DEMONSTRATION 2

A steel ball was shown to be capable of applying a stress and to cause a strain in a spring. The strain was displayed as an effect of the stress, which was detectable as a change in the length of the spring.

27.

The stretching of a spring is called a STRAIN. The pull applied to the spring is called a STRESS.

28.

The sag in a mattress is called a STRAIN, but the downward force which causes the sag is called a STRESS.

29.

The weight of some clothes pulling down on a clothesline is called a STRESS because it causes a STRAIN in the clothesline.

30.

A push against a cushion causes a sag in the cushion. The stress in this case is the PUSH. The strain is the SAG.

DEMONSTRATION 3

A spring was shown to undergo different strains as a result of the application of two different amounts of stress. The stresses were produced by metal balls of different sizes and weights; the strains were measurable as inch-units on a scale behind the spring. The point was made here that the greater stress led to a greater strain.

31.

When more than one person gets on a trampoline, the stress is increased. When the stress gets bigger, the STRAIN on the trampoline INCREASES.

32.

Pulling down harder on a spring is one way to increase the stress. When you increase the stress, the STRAIN in the spring also INCREASES.

33.

Comparing the strains caused in a spring by a strong pull and a weak pull, the strain caused by the weak pull is SMALLER than the strain caused by the strong pull.

34.

If you wanted to decrease the strain in a ball you would have to DECREASE the stress (use less stress). To increase the strain on a bow, you have to INCREASE THE STRESS.

DEMONSTRATION 4

A perfectly elastic and non-elastic object were each subjected to a stress. Only the former was shown to regain its original shape when the stress was removed.

35.

When the stress is removed, a rubber ball returns to its original shape, but a putty ball does not return to its ORIGINAL SHAPE.

36.

You can cause a strain in a heavy spring by applying a stress, but when the stress is removed the spring will RETURN TO ITS ORIGINAL SHAPE.

37.

An object which returns to its original shape when the stress is removed is called a perfectly elastic object. A spring which returns to its original shape after a stress is removed is called a PERFECTLY ELASTIC spring.

38.

A ball which returns to its original shape when a stress is removed would be called a PERFECTLY ELASTIC ball.

39.

A fender fails to return to its original shape when the stress is removed; it remains dented. The fender would NOT be called a PERFECTLY ELASTIC object.

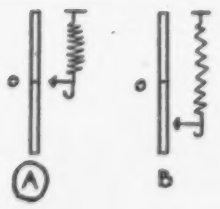
40.

When the stress is removed from a perfectly elastic ball, the ball will RETURN to its ORIGINAL SHAPE.

DEMONSTRATION 5

Two identical-appearing springs were shown to undergo strains as the result of identical weights being hung on them. One returned to its original length when the weight was removed, the other remained stretched. The students were directed to select the spring which was perfectly elastic.

41.



. . . because, when the stress was removed, THE SPRING RETURNED TO ITS ORIGINAL SHAPE.

42.

A piece of putty is not perfectly elastic because, after you remove the stress, the putty WILL NOT RETURN TO ITS ORIGINAL SHAPE.

43.

When the stress is removed from a perfectly elastic object, the object RETURNS TO ITS ORIGINAL SHAPE.

RELATIONSHIPS PROGRAM*

DEMONSTRATION 1

Two examples were given of physical changes: a balloon was shown to change in size, and a container of fluid to change in weight.

1.

When a man gains weight we say that a change has occurred in his weight. When he loses weight, we also say that a CHANGE has occurred in his WEIGHT.

2.

When a boy grows taller, a CHANGE has occurred in his HEIGHT. When the weight of any object increases or decreases, we say that a CHANGE HAS OCCURRED.

3.

If an increase is a change in one direction, then a decrease is a change in the OPPOSITE direction.

4.

If the price of candy goes up, this is a change in one direction. If the price of candy goes down, this is a change in the OPPOSITE DIRECTION.

DEMONSTRATION 2

A piece of clay was shown to undergo changes when it was halved: it changed in size and in weight. Size and weight were described as having changed in the same direction.

5.

If temperature goes up and humidity goes up we say that they have changed in the same direction. If temperature goes down and humidity goes down we also say they have CHANGED in the SAME DIRECTION.

6.

If rainfall increases and produces a bigger wheat crop, we say that they have CHANGED in the SAME DIRECTION. If rainfall decreases and produces a smaller wheat crop, we also say they have CHANGED IN THE SAME DIRECTION.

7.

If two things get bigger together, we say they have CHANGED IN THE SAME DIRECTION. If two things get smaller together, we say they have CHANGED IN THE SAME DIRECTION.

8.

If the amount of electricity used and the size of the electric bill change in the same direction, it means that the more electricity used, the BIGGER YOUR BILL WILL BE.

9.

When two things change in the same direction, we say they are directly related. If rainfall increases and the size of a wheat crop increases, we say they are DIRECTLY RELATED.

10.

Because an increase in weight usually results in an increase in a man's size, we say that weight and size are DIRECTLY RELATED.

*Included among the frames is a brief description of each demonstration at the point at which it occurred in the television lessons. The frames presented here correspond to: (1) the Fully Prompted version of the lesson, and (2) the form employed as confirmation frames in the other versions.

11.

The more studying you do, the higher your grades are. Thus, your studying and your GRADES are said to be DIRECTLY RELATED.

12.

When two things change in the same direction, we say that THEY ARE DIRECTLY RELATED.

13.

Two things are directly related if one of them increases and the other also INCREASES. This means they have changed in the SAME DIRECTION.

14.

When A and B are directly related, it means they have both CHANGED in the SAME DIRECTION. That is, if A increases B also INCREASES. If A decreases B also DECREASES.

15.

When we say size and weight are directly related, it means that they both CHANGE IN THE SAME DIRECTION. That is, if size increases, WEIGHT INCREASES and if size decreases, WEIGHT DECREASES.

16.

The amount of exercise you get and how healthy you are are directly related. This means that the MORE exercise you get, the HEALTHIER YOU WILL BE.

17.

Age and experience are directly related. This means that THE OLDER YOU ARE THE MORE EXPERIENCED YOU ARE.

18.

When two things change in the same direction, they are DIRECTLY RELATED.

DEMONSTRATION 3

Two glass columns were shown, side by side, each with a fluid level of equal height. The fluid level was then lowered in one and raised in the other. The point was made that the levels changed in opposite directions, one having gone down, the other up.

19.

When temperature increases and humidity decreases, they have changed in opposite directions. If one goes up and the other goes down, they have changed in OPPOSITE DIRECTIONS.

20.

If temperature goes from 75° to 85°, but humidity goes from 60% to 40%, we say they are inversely related. When two things change in OPPOSITE DIRECTIONS, we say they are INVERSELY related.

21.

When a person's weight goes up, his speed in running tends to go down. They change in OPPOSITE DIRECTIONS. Therefore, we say that weight and speed are INVERSELY RELATED.

22.

If the price of a movie goes up and attendance goes down, we say they are INVERSELY RELATED because they CHANGE IN OPPOSITE DIRECTIONS.

23.

When we say weight and speed are inversely related, it means that they CHANGE IN OPPOSITE DIRECTIONS. That is, if weight increases, SPEED DECREASES and if weight decreases, SPEED INCREASES.

24.

A and B are inversely related when they CHANGE IN OPPOSITE DIRECTIONS. This means that if A increases, B DECREASES; and if A decreases, B INCREASES.

25.

The speed at which you work and how accurate your work is are inversely related. This means that the faster you work, the LESS ACCURATE YOUR WORK IS.

26.

If one object increases in size and the other decreases in size, they change in OPPOSITE DIRECTIONS. If two boys both increase their weight, the weights of the boys change in the SAME DIRECTION.

27.

Things are inversely related when they CHANGE IN OPPOSITE DIRECTIONS. Things are directly related when they CHANGE IN THE SAME DIRECTION.

DEMONSTRATION 4

Two successive examples were shown of four and then six apples, to be divided between two men. Objects were arranged in the form of an equation. It was pointed out that as the total number of apples increased, the number for each man also increased; the total and the number for each man thus being directly related.

28.

(1) $\frac{12 \text{ apples}}{2 \text{ men}}$ = 6 apples for each man

(2) $\frac{16 \text{ apples}}{2 \text{ men}}$ = 8 apples for each man

When the number of apples increased from example (1) to example (2) in your booklet, the number of apples for each man also INCREASED. This means that they are DIRECTLY RELATED.

29.

(a) $\frac{\text{numerator } (20)}{\text{denominator } (5)}$ = answer (4)

(b) $\frac{\text{numerator } (25)}{\text{denominator } (5)}$ = answer (5)

Compare the examples in your booklet. The numerator and the answer are DIRECTLY RELATED. The numerator increases from 20 to 25, and the answer also INCREASES from 4 to 5.

30.

$$\frac{\text{numerator } (20)}{(5)} = \text{answer } (4)$$

If the numerator decreases, the answer will also DECREASE because the NUMERATOR and the ANSWER are DIRECTLY RELATED.

31.

$$\frac{\text{numerator } (30)}{(5)} = \text{answer } (6)$$

The two parts which are directly related are the NUMERATOR and the ANSWER. This means that if one INCREASES the other will also INCREASE.

32.

$$\frac{M}{R} = Q$$

If M increases, Q will INCREASE; and if M decreases, Q will DECREASE because M AND Q ARE DIRECTLY RELATED.

33.

Because the numerator and the answer are directly related, they will change in the SAME DIRECTION.

34.

The numerator and the answer are DIRECTLY RELATED. That means they will CHANGE IN THE SAME DIRECTION.

35.

(a) $\frac{(15)}{\text{denominator } (3)}$ = answer (5)

(b) $\frac{(15)}{\text{denominator } (5)}$ = answer (3)

When the denominator increases from (3) to (5), the answer decreases from (5) to (3). They do NOT change in the SAME DIRECTION.

36.

(a) $\frac{(30)}{\text{denominator } (15)}$ = answer (2)

(b) $\frac{(30)}{\text{denominator } (10)}$ = answer (3)

The denominator and the answer change in opposite directions. This means that the denominator has decreased but the answer has INCREASED.

37.

The denominator and the answer are inversely related. This means that if the denominator increases, the answer will DECREASE. It also means that if the denominator decreases, the answer will INCREASE.

38.

$$\frac{M}{P} = Q$$

If P increases, Q will DECREASE and if P decreases, Q will INCREASE because the denominator and answer are INVERSELY RELATED.

39.

The denominator and the answer are INVERSELY RELATED. This means they change in OPPOSITE directions.

40.

The denominator and the answer change in opposite directions. This means that there is an inverse relation between the DENOMINATOR and the ANSWER.

41.

There is an inverse relation between the DENOMINATOR and the ANSWER. This means they change in OPPOSITE DIRECTIONS.

42.

Because the denominator and the answer are inversely related, they change in OPPOSITE DIRECTIONS. Because the numerator and the answer are directly related, they change in the SAME DIRECTION.

43.

$$\frac{R}{S} = T$$

If S changes in one direction, T will
CHANGE IN THE OPPOSITE DIRECTION.

44.

$$\frac{R}{S} = T$$

What will happen if R increases?
T WILL INCREASE.
What will happen if S increases?
T WILL DECREASE.

ELASTICITY TEST

1. What causes a strain? _____

2. There can be more strain in an object in some situations than there is in others. What is this due to?

_____

_____

3. How can you get rid of a strain in an object? _____

_____

4. It is possible to get rid of the strain for a certain kind of object. What is this kind of object called? _____

5. Kicking a football causes a momentary dent in the ball as it flies off your foot. What is the stress in this situation?

_____

What is the strain? _____

6. As a car rolls over some snow, the snow is packed down. What is the stress in this situation?

_____

What is the strain? _____

7. Describe the behavior of an object which would indicate that the object was not perfectly elastic.

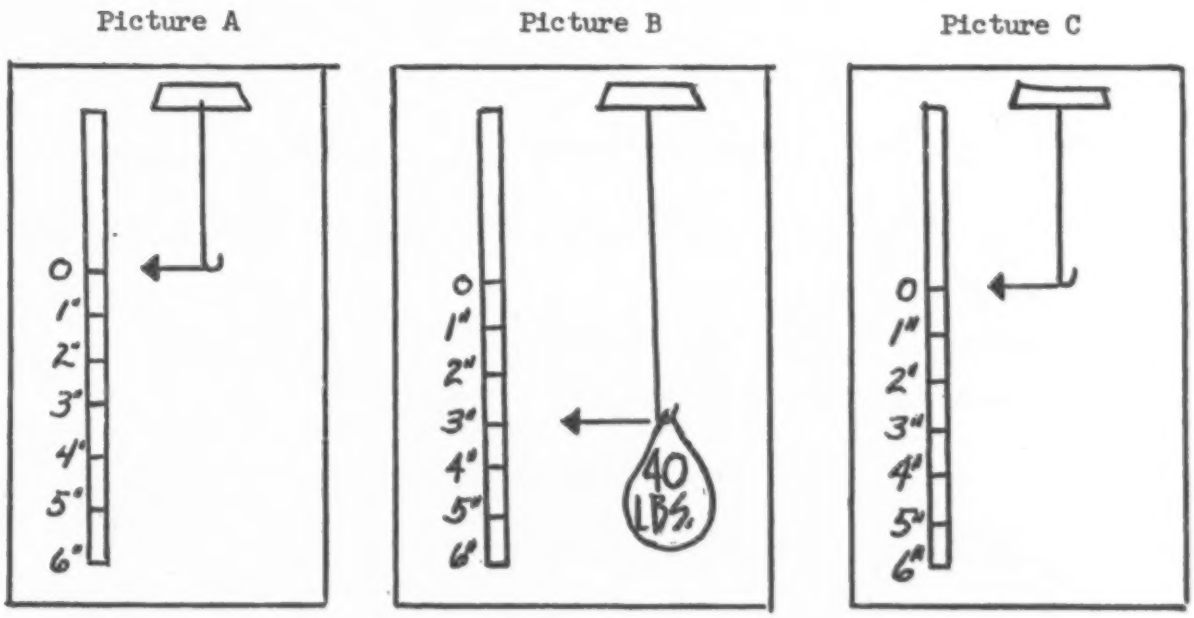
_____

_____

8. Indicate which object, A or B, would cause more strain in a tennis ball and explain why.

_____

9. Picture A shows a nylon cord hanging from a beam. In picture B, a 40-lb. sack of sand has been hung on the cord. In picture C, the sack has been removed.



1. How much stress is shown in Picture B? _____

2. How much strain is shown in Picture B? _____

3. What kind of nylon cord would this be called? _____

RELATIONSHIPS TEST

Part I

1. When two things change in the same direction, together, they are said to be _____.

2. For the equation: $\frac{D}{E} = F$, give the special term which describes the relationship: between D and F _____,
between E and F _____.

3. In the equation: $\frac{X}{Y} = Z$, if X changes in one direction, Z will _____.

4. A increases as B increases. Give the term which describes the relationship between A and B. _____

5. When two things change in opposite directions, together, they are said to be _____.

6. In the equation: $\frac{A}{B} = C$, if B changes in one direction, C will _____.

7. C gets larger as D gets smaller. Give the term which describes the relationship between C and D. _____

8. $\frac{M}{N} = O$

If we reduce N, what will happen to O? _____

9. In the equation: $\frac{S}{T} = U$, the quantities _____ and _____ change in the same direction, thus we say that they are _____.
On the other hand, the quantities _____ and _____ change in opposite directions and we say that they are _____.

Relationships - Part II

1. The price of fruit is inversely related to the size of the crop. Explain what this means.

_____

_____

_____

2. Temperature and speed of chemical reactions are directly related. What would you do to slow down a chemical reaction?

_____

_____

3. For gases, pressure and volume are inversely related. What would you do to increase the volume of a gas?

_____

4. Give an example, other than the one in question 2, of two things which are directly related and explain what you mean by this.

_____

_____

_____

APPENDIX B

Additional Results

Table 1-B

Summary Results for the Matching of Ss by IQ and Work Rate Across Tempo and Prompting Conditions (N = 252)

	Levels of Independent Variables	IQ (Otis Group) Mean	IQ (Otis Group) S.D.	Work Rate Mean	Work Rate S.D.
TEMPO	Base	109.89	10.63	95.73	19.35
	Base -1	110.79	10.73	95.83	15.11
	Base -2	110.30	9.66	94.97	20.33
	Base -3	110.92	10.79	93.83	15.44
PROMPTING	Non-Prompted	111.15	9.62	94.40	15.60
	Extra Prompts	110.29	10.20	95.70	19.08
	Fully-Prompted	109.99	11.42	95.15	18.18

Table 2-B

Summary of the Analysis of Variance: The Matching of Ss by IQ Across Tempo and Prompting Conditions (N = 252)

Source	D.F.	Mean Square	F
A - Tempo	3	14.15	-
B - Prompting	2	30.87	-
AB	6	10.10	-
Within	240	112.66	

Table 3-B

Summary of the Analysis of Variance: The Matching of Ss by Work Rate Across Tempo and Prompting Conditions (N = 252)

Source	D.F.	Mean Square	F
A - Tempo	3	53.86	-
B - Prompting	2	35.65	-
AB	6	46.11	-
Within	240	322.57	

Table 4-B

Summary Results for the Matching of Ss by IQ and Work Rate for the Non-Prompted Condition Only (N = 32)

	Levels of Independent Variables	IQ (Otis Group) Mean	S.D.	Work Rate Mean	S.D.
TEMPO	Slow	112.75	6.91	99.75	16.81
	Fast	114.06	7.46	96.69	15.29
WORK RATE	Fast	113.44	6.50	83.94	5.56
	Slow	113.38	7.88	112.50	7.44
IQ	High	119.19	3.49	97.19	14.34
	Low	107.63	4.57	99.25	17.70

Table 5-B

Summary of the Analysis of Variance: The Matching of Ss by IQ for the Non-Prompted Condition Only (N = 32)

Source	D.F.	Mean Square	F
A - Tempo	1	1378.12	-
B - Work Rate	1	3.12	-
C - IQ	1	106953.12	56.45**
AB	1	153.12	-
AC	1	253.12	-
BC	1	703.12	-
ABC	1	1653.12	-
Within	24	1894.79	

**significant beyond the .01 level

Table 6-B

Summary of the Analysis of Variance: The Matching of Ss by Work Rate for the Non-Prompted Condition Only (N = 32)

Source	D.F.	Mean Square	F
A - Tempo	1	7503.12	1.64
B - Work Rate	1	652653.12	14.30**
C - IQ	1	3403.12	-
AB	1	28.12	-
AC	1	703.12	-
BC	1	8128.12	1.78
ABC	1	3.06	-
Within	24	4563.54	

**significant beyond the .01 level

Table 7-B

Summary Results for the Matching of Ss by IQ and Work Rate for Selected Cases Across all Tempo and Prompting Conditions (N = 96)

	Levels of Independent Variables	IQ (Otis Group) Mean	IQ (Otis Group) S.D.	Work Rate Mean	Work Rate S.D.
PROMPTING	Non-Prompted	113.41	7.11	98.22	15.88
	Extra Prompts	113.34	8.84	101.09	19.08
	Fully-Prompted	113.81	9.97	98.81	16.97
TEMPO	Slow	113.58	8.08	99.69	17.09
	Fast	113.46	9.22	99.06	17.53
WORK RATE	Fast	113.52	7.59	84.25	6.19
	Slow	113.52	9.64	114.50	9.70
IQ	High	120.63	4.15	98.92	16.50
	Low	106.42	5.49	99.83	18.08

Table 8-B

Summary of the Analysis of Variance: The Matching of Ss by IQ Across all Tempo and Prompting Conditions (N = 96)

Source	D.F.	Mean Square	F
A - Prompting	2	207.29	-
B - Tempo	1	37.50	-
C - Work Rate	1	.00	-
D - IQ	1	484504.16	183.55**
AB	2	1415.62	-
AC	2	21.88	-
AD	2	4769.79	1.81
BC	1	266.67	-
BD	1	4004.17	1.52
CD	1	5400.00	2.01
ABC	2	1588.54	-
ABD	2	357.29	-
ACD	2	846.87	-
BCD	1	816.66	-
ABCD	2	1750.99	-
Within	72	2639.58	

**significant beyond the .01 level

Table 9-B

Summary of the Analysis of Variance: The Matching of Ss by Work Rate Across all Tempo and Prompting Conditions (N = 96)

Source	D.F.	Mean Square	F
A - Prompting	2	7371.88	-
B - Tempo	1	937.50	-
C - Work Rate	1	2196150.00	274.23**
D - IQ	1	2016.67	-
AB	2	3603.12	-
AC	2	2896.88	-
AD	2	1013.54	-
BC	1	37.50	-
BD	1	37.50	-
CD	1	4266.66	-
ABC	2	65.62	-
ABD	2	490.62	-
ACD	2	3251.06	-
BCD	1	204.19	-
ABCD	2	207.28	-
Within	72	8008.33	

**significant beyond the .01 level

Table 10-B

Summary Results of Raw Error Scores
on the Elasticity Program
by Levels of Each Independent Variable
(N = 64)

	Levels of Independent Variables	Mean	S.D.
PROMPTING	Non-Prompted	22.28	14.37
	Extra Prompts	16.47	9.99
TEMPO	Slow	13.13	11.15
	Fast	25.63	10.93
WORK RATE	Fast	16.91	9.39
	Slow	21.84	14.93
IQ	High	18.03	15.42
	Low	20.72	9.07

Table 11-B

Summary Results of Raw Error Scores
on the Relationships Program
by Levels of Each Independent Variable
(N = 64)

	Levels of Independent Variables	Mean	S.D.
PROMPTING	Non-Prompted	12.53	11.51
	Extra Prompts	8.75	7.32
TEMPO	Slow	5.63	5.63
	Fast	15.66	10.48
WORK RATE	Fast	8.84	7.15
	Slow	12.44	11.65
IQ	High	9.59	10.53
	Low	11.69	8.96

Table 12-B

Summary of the Covariance Analysis
for Log Error Scores on the Elasticity Program[1]
(N = 64)

Source	D.F.	Mean Squares	F
A - Prompting	1	.49	2.60
B - Tempo	1	2.10	11.45**
C - Work Rate	1	.24	-
D - IQ	1	1.02	5.55*
AB	1	.02	-
AC	1	.02	-
AD	1	.14	-
BC	1	.07	-
BD	1	.05	-
CD	1	.05	-
ABC	1	.02	-
ABD	1	.01	-
ACD	1	.00	-
BCD	1	.01	-
ABCD	1	.00	-
Within	47	.18	

**significant beyond the .01 level
*significant beyond the .05 level

Table 13-B

Summary of the Covariance Analysis
for Log Error Scores on the Relationships Program[1]
(N = 64)

Source	D.F.	Mean Squares	F
A - Prompting	1	.45	1.60
B - Tempo	1	4.72	16.93**
C - Work Rate	1	.03	-
D - IQ	1	.64	2.30
AB	1	.00	-
AC	1	.02	-
AD	1	.04	-
BC	1	.86	3.09
BD	1	.02	-
CD	1	.02	-
ABC	1	.01	-
ABD	1	.01	-
ACD	1	.02	-
BCD	1	.02	-
ABCD	1	.03	-
Within	47	.28	

**significant beyond the .01 level

[1]Pretest scores were used as the covariate.

Table 14-B

Summary Results for Posttest Scores
on the Elasticity Program
by Levels of Each Independent Variable
(N = 96)

	Levels of Independent Variables	Mean
PROMPTING	Non-Prompted	10.25
	Extra Prompts	12.01
	Fully-Prompted	10.02
TEMPO	Slow	11.01
	Fast	10.52
WORK RATE	Fast	10.65
	Slow	10.88
IQ	High	10.93
	Low	10.59

Table 15-B

Summary Results for Posttest Scores
on the Relationships Program
by Levels of Each Independent Variable
(N = 96)

	Levels of Independent Variables	Mean
PROMPTING	Non-Prompted	15.85
	Extra Prompts	12.65
	Fully-Prompted	13.46
TEMPO	Slow	14.48
	Fast	13.49
WORK RATE	Fast	14.24
	Slow	13.74
IQ	High	15.11
	Low	12.86

Table 16-B

Summary of the Covariance Analysis
for Immediate Posttest Scores on the Elasticity Program[1]
(N = 96)

Source	D.F.	Mean Squares	F
A - Prompting	2	9275.84	3.40*
B - Tempo	1	101.76	-
C - Work Rate	1	2097.56	-
D - IQ	1	320.24	-
AB	2	2513.87	-
AC	2	2065.40	-
AD	2	312.03	-
BC	1	7857.56	2.88
BD	1	3941.23	1.45
CD	1	29.31	-
ABC	2	2300.45	-
ABD	2	5922.12	2.17
ACD	2	3995.24	1.50
BCD	1	1295.99	-
ABCD	2	3128.94	1.15
Within	71	2724.19	

*significant beyond the .05 level

Table 17-B

Summary of the Covariance Analysis
for Immediate Posttest Scores on the Relationships Program[1]
(N = 96)

Source	D.F.	Mean Squares	F
A - Prompting	2	9393.50	8.07**
B - Tempo	1	2923.94	2.51
C - Work Rate	1	395.34	-
D - IQ	1	13678.44	11.75**
AB	2	794.09	-
AC	2	153.76	-
AD	2	5673.44	4.84*
BC	1	89.58	-
BD	1	81.67	-
CD	1	3288.92	2.82
ABC	2	290.35	-
ABD	2	4701.26	4.04*
ACD	2	2012.27	1.73
BCD	1	.07	-
ABCD	2	2453.43	2.11
Within	71	1164.28	

**significant beyond the .01 level
*significant beyond the .05 level

[1]Pretest scores were used as the covariate in each case.

Table 18-B

Summary Results for Retention Test Scores
on the Elasticity Program
by Levels of Each Independent Variable
(N = 96)

	Levels of Independent Variables	Mean
PROMPTING	Non-Prompted	10.75
	Extra Prompts	9.80
	Fully-Prompted	9.05
TEMPO	Slow	10.15
	Fast	9.59
WORK RATE	Fast	9.55
	Slow	10.17
IQ	High	10.81
	Low	8.92

Table 19-B

Summary Results for Retention Test Scores
on the Relationships Program
by Levels of Each Independent Variable
(N = 96)

	Levels of Independent Variables	Mean
PROMPTING	Non-Prompted	9.12
	Extra Prompts	7.59
	Fully-Prompted	9.71
TEMPO	Slow	8.87
	Fast	8.54
WORK RATE	Fast	8.29
	Slow	9.34
IQ	High	9.17
	Low	8.45

Table 20-B

Summary of the Covariance Analysis
for Retention Scores on the Elasticity Program[1]
(N = 96)

Source	D.F.	Mean Squares	F
A - Prompting	2	2327.41	2.56
B - Tempo	1	730.44	-
C - Work Rate	1	923.30	1.01
D - IQ	1	9029.23	9.90**
AB	2	108.15	-
AC	2	825.74	-
AD	2	1136.36	1.25
BC	1	3179.32	3.49
BD	1	1706.08	1.87
CD	1	46.10	-
ABC	2	69.70	-
ABD	2	2221.18	2.44
ACD	2	3012.00	3.31*
BCD	1	1827.03	2.00
ABCD	2	343.58	-
Within	71	911.77	

**significant beyond the .01 level
*significant beyond the .05 level

Table 21-B

Summary of the Covariance Analysis
for Retention Scores on the Relationships Program[1]
(N = 96)

Source	D.F.	Mean Squares	F
A - Prompting	2	3750.20	2.24
B - Tempo	1	57.49	-
C - Work Rate	1	2797.70	1.67
D - IQ	1	1174.24	-
AB	2	324.14	-
AC	2	1491.60	-
AD	2	320.70	-
BC	1	4670.77	2.79
BD	1	2.04	-
CD	1	13216.13	7.91*
ABC	2	2840.96	-
ABD	2	3666.50	2.19
ACD	2	1302.07	-
BCD	1	.33	-
ABCD	2	291.16	-
Within	71	1671.04	

*significant beyond the .05 level

[1]Pretest scores were used as the covariate in each case.

Table 22-B

Summary Results of Unadjusted Error Scores
on the Elasticity Program
by Levels of Each Independent Variable
(N = 96)

	Levels of Independent Variables	Mean	S.D.
TEMPO	Base	10.46	12.53
	B -1	15.50	7.19
	B -2	21.25	12.79
	B -3	28.46	13.43
PROMPTING	Non-Prompted	22.15	15.30
	Extra Prompts	15.69	10.33
WORK RATE	Fast	15.46	9.95
	Slow	22.38	15.45

Table 23-B

Summary Results of Unadjusted Error Scores
on the Relationships Program
by Levels of Each Independent Variable
(N = 96)

	Levels of Independent Variables	Mean	S.D.
TEMPO	Base	4.17	5.20
	B -1	9.67	9.42
	B -2	13.79	12.87
	B -3	18.54	12.98
PROMPTING	Non-Prompted	14.58	14.34
	Extra Prompts	8.50	7.27
WORK RATE	Fast	8.88	8.31
	Slow	14.21	13.92

Table 24-B

Summary of Double Covariance Analyses
for Log Error Scores on the Elasticity Program[1]
(N = 96)

Source	D.F.	Mean Squares	F
A - Tempo	3	1.70	10.88***
B - Prompting	1	.63	4.07*
C - Work Rate	1	.22	1.41
AB	3	.03	-
AC	3	.10	-
BC	1	.01	-
ABC	3	.02	-
Within	78	.16	

***significant beyond the .001 level
*significant beyond the .05 level

Table 25-B

Summary of Double Covariance Analyses
for Log Error Scores on the Relationships Program[1]
(N = 96)

Source	D.F.	Mean Squares	F
A - Tempo	3	4.08	11.09***
B - Prompting	1	1.90	5.17*
C - Work Rate	1	.06	-
AB	3	.08	-
AC	3	.24	-
BC	1	.22	-
ABC	3	.62	1.69
Within	78	.37	

***significant beyond the .001 level
*significant beyond the .05 level

[1]Pretest scores and IQ were used as covariates in this analysis.

Table 26-B

Summary Results of Unadjusted Posttest Scores
on the Elasticity Program
by Levels of Each Independent Variable
(N = 144)

	Levels of Independent Variables	Mean	S.D.
TEMPO	Base	11.97	3.19
	Base -1	10.14	2.68
	Base -2	11.21	2.87
	Base -3	10.71	3.17
PROMPTING	Non-Prompted	10.92	3.17
	Extra Prompts	11.27	3.04
	Fully-Prompted	10.83	2.93
WORK RATE	Fast	11.55	2.86
	Slow	10.47	3.12

Table 27-B

Summary Results of Unadjusted Posttest Scores
on the Relationships Program
by Levels of Each Independent Variable
(N = 144)

	Levels of Independent Variables	Mean	S.D.
TEMPO	Base	15.00	3.95
	Base -1	14.18	4.39
	Base -2	14.63	4.45
	Base -3	13.31	4.51
PROMPTING	Non-Prompted	15.54	3.50
	Extra Prompts	13.32	4.44
	Fully-Prompted	13.97	4.74
WORK RATE	Fast	14.84	4.16
	Slow	13.72	4.46

Table 28-B

Summary of Double Covariance Analyses
for Posttest Scores on the Elasticity Program[1]
(N = 144)

Source	D.F.	Mean Squares	F
A - Tempo	3	2053.77	2.80*
B - Prompting	2	472.37	-
C - Work Rate	1	212.73	-
AB	6	372.64	-
AC	3	996.08	1.36
BC	2	251.38	-
ABC	6	303.23	-
Within	118	733.05	

*significant beyond the .05 level

Table 29-B

Summary of Double Covariance Analyses
for Posttest Scores on the Relationships Program[1]
(N = 144)

Source	D.F.	Mean Squares	F
A - Tempo	3	2216.90	1.94
B - Prompting	2	5844.19	5.10**
C - Work Rate	1	55.07	-
AB	6	782.64	-
AC	3	2382.39	2.08
BC	2	1823.64	1.59
ABC	6	680.24	-
Within	118	1145.25	

**significant beyond the .01 level

[1]Pretest scores and IQ were used as covariates in this analysis.

Table 30-B

Summary Results of Unadjusted Retention Scores
on the Elasticity Program
by Levels of Each Independent Variable
(N = 144)

	Levels of Independent Variables	Mean	S.D.
TEMPO	Base	10.43	3.37
	Base -1	9.97	3.04
	Base -2	9.89	3.58
	Base -3	9.75	3.50
PROMPTING	Non-Prompted	10.65	2.93
	Extra Prompts	9.68	3.47
	Fully-Prompted	9.71	3.50
WORK RATE	Fast	10.18	3.30
	Slow	9.84	3.42

Table 31-B

Summary Results of Unadjusted Retention Scores
on the Relationships Program
by Levels of Each Independent Variable
(N = 144)

	Levels of Independent Variables	Mean	S.D.
TEMPO	Base	8.82	4.18
	Base -1	8.19	4.44
	Base -2	9.19	5.17
	Base -3	8.71	3.98
PROMPTING	Non-Prompted	8.82	4.29
	Extra Prompts	8.05	4.15
	Fully-Prompted	9.31	4.83
WORK RATE	Fast	8.85	4.24
	Slow	8.61	4.64

Table 32-B

Summary of Double Covariance Analyses
for Retention Scores on the Elasticity Program[1]
(N = 144)

Source	D.F.	Mean Squares	F
A - Tempo	3	234.12	-
B - Prompting	2	2160.62	2.34
C - Work Rate	1	512.12	-
AB	6	377.78	-
AC	3	1526.29	1.65
BC	2	470.72	-
ABC	6	1578.11	1.71
Within	118	922.43	

Table 33-B

Summary of Double Covariance Analyses
for Retention Scores on the Relationships Program[1]
(N = 144)

Source	D.F.	Mean Squares	F
A - Tempo	3	829.78	-
B - Prompting	2	1552.99	1.04
C - Work Rate	1	1555.54	1.04
AB	6	2864.68	1.92
AC	3	4093.25	2.74*
BC	2	1531.03	1.03
ABC	6	1057.49	-
Within	118	1492.38	

*significant beyond the .05 level

[1]Pretest scores and IQ were used as covariates in this analysis.